POWER

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Help Yourself

By Rufus T. Strohm

WE'RE apt to be filled with envy
At the mention of the chap
Whom circumstance, by a lucky chance,
Has tossed into Fortune's lap;
For the ordinary mortal
Is a poor and hapless elf,
And the best that he can expect to see
Is a way to help himself.

IT'S a comfort to the climber
Who would scale the mountain wall
To know a friend is at hand to lend
Swift help should he chance to fall;
But the man who scans most keenly
Each inch of the rocky shelf
Is the lonely wight on the dizzy height
Who is forced to help himself.

THE strides that the race is making
In its struggle toward the light
Have come by the throes and the sweat of those
Who have had to work and fight;
For earth doesn't owe its progress
To the Guildford or the Guelph,
But in shire and town to a Jones or Brown
Who has learned to help himself.

THE gawk who inherits millions
Has a cheap cause to be vain,
Since not one sou of the sum is due
To his use of brawn or brain;
But the engineer who labors
As he garners in the pelf
Has the cheering thought that his wealth is wrought
By the way he helps himself.

Ninety-Five Thousand Kilowatt

The Commonwealth Edison Co., of Chicago is completing the installation at Northwest Station of three additional turbo-generators of an aggregate capacity of 95,000 kw. Two are of the compound reaction type and the third an impulse machine of new design. One of each type is now in operation, and the second compound machine is in course of erection. At the turbine throttle steam is supplied at a pressure of 230 lb. gage and 200 deg. superheat.

WITH the present installation of three turbo-generators, two with a rating of 30,000 kw. and one of 35,000 kw., Northwest Station of the Commonwealth Edison Co., Chicago, Ill., will have an aggregate rated capacity of 165,000 kw. The plans calling for six units will have been completed, and the present building fully occupied.

As previously recorded in these columns, the station was first equipped with two 20,000-kw. vertical machines generating 25-cycle current. The next addition was unit No. 3, a horizontal compound turbine, with the double-flow low-pressure element in a separate casing, driving a 30,000-kw. 25-cycle generator. In service this machine has been found to have ample capacity for continuous operation at 35,000 kw. Full details of the unit are available in the June 20, 1916, issue of *Power*.

Of the three new units No. 4 (see headpiece above and Fig. 3) consists of an impulse turbine arranged in a single casing and a 25-cycle three-phase generator rated at 35,000 kw. at unity power factor. Units Nos. 5 and 6 consist each of a compound reaction turbine driving a 60-cycle three-phase generator (see headpiece on opposite page) rated to deliver 30,000 kw. at 85 per cent. power factor.

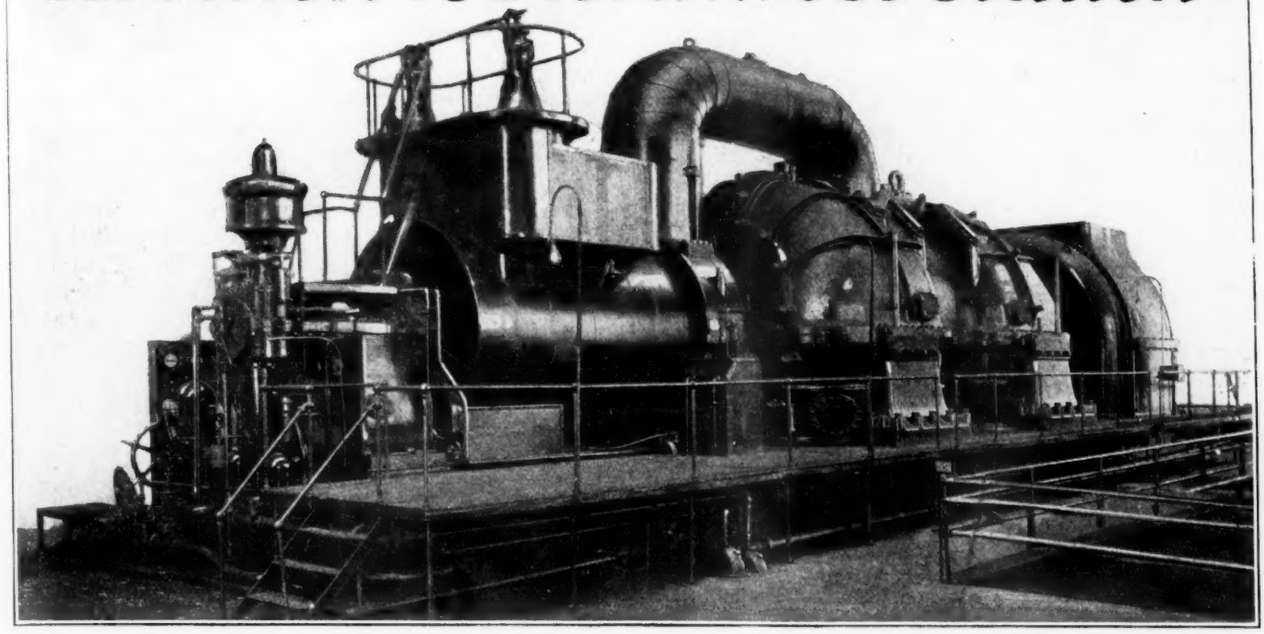
Unit No. 6 was the first of the new machines to be placed in service, and No. 5, now in the course of erection, will be a duplicate. The turbine is of tandem-compound design, the two rotating elements being connected by a solid flanged coupling. The generator is in turn connected through a flexible coupling so that all three rotors turn as one unit, in contradistinction to the cross-compound type, where each element of the turbine drives a separate generator. There are five main bearings, three on the turbine and two on the generator, with an additional small bearing on the outboard end of the direct-connected exciter. All bearings are served by the usual system of oil circulation. Normal oil temperature is maintained by an oil cooler supplied with water from the condenser circulating-water system. There are no cooling coils in the individual bearings.

The shaft packing consists of the well-known water gland with a steam labyrinth added, by means of which vacuum may be established before placing the turbine in operation. After sufficient speed is attained, the water gland is put in operation and the steam labyrinth shut off.

The high-pressure element of the turbine, which contains the governor and valve mechanism, is of standard single-flow pure reaction construction, containing a total of 90 rows of rotating and stationary blading. In this element the steam expands from the throttle pressure of 230 lb. gage down to a pressure of about 34 lb. absolute, at the most economical load. The steam passes next through an exhaust at the top of the cylinder into an overhead passage leading to the low-pressure element.

In the low-pressure element there is a combination of single- and double-flow construction, employing all-reaction blading. Steam from the high-pressure element enters at the top near the center and passes through a single-flow stage consisting of 20 stationary and

Addition to Northwest Station



rotating rows of blading, expanding from a pressure of 34 lb. absolute to approximately 8.5 lb. absolute. It is then divided, one half continuing through an adjacent low-pressure stage consisting of 16 rotating and stationary rows of blading, while the other half passes back around the single-flow stage, through passages between the inner and outer cylinders, to a duplicate pressure stage on the opposite end of the spindle. Each low-pressure stage has its separate exhaust passage to a condenser.

Steam admission is controlled by means of standard Westinghouse control mechanism, consisting of a governor controlling the main or primary steam-admission valve and two overload valves through an oil relay. The designed capacity on the primary valve is 25,000 kw., this being the point of maximum efficiency. The designed capacity on the secondary is 30,000 kw., and on the tertiary, 35,000 kilowatts.

The turbine is served by two condensers, shown to the right in Fig. 1, containing 28,000 sq.ft. each, or a total of 56,000 sq.ft. of cooling surface, in 12,972 tubes 1 in. in diameter and 16.5 ft. long between tube heads. The surface is disposed equally between the two shells, each taking steam from one of the low-pressure elements. On a basis of 30,000 kw. the condenser has 1.87 sq.ft. of surface per kilowatt.

At the entrance to each shell is a primary heater containing 750 sq.ft. of surface through which the condensate is passed, so that it may be heated to substantially the temperature of the exhaust steam. A bi-rotor circulating pump direct-connected to a 600-hp. induction motor (at the left in Fig. 1) furnishes cooling water to both sections of the condenser. This pump, when running at a speed of 350 r.p.m., has capacity to deliver 60,000 gal. of water per minute against a head of 18 feet.

Each shell of the condenser is served by a condensate pump and a hydraulic air pump of the Leblanc type, Fig. 2. Both pumps are turbine-driven on a common shaft. Each of these auxiliary sets is of sufficient size to serve the main unit when operating at its maximum capacity, thus giving one set for reserve. The condensate is pumped through the condenser preheater and to the feed-water heater. From the heater the feed water passes through the boiler-feed pumps and thence through the economizers to the five boilers of the unit.

The makeup water, which serves to supply any deficiency in the boiler feed, is drawn from a fresh-water reservoir in which is collected the heater overflow, trap discharges and condensation that would otherwise be wasted. At such times as the supply of condensation to the fresh-water reservoir is insufficient, filtered water is admitted through a float valve. The makeup water is drawn from this reservoir into the condenser by the vacuum, the amount being regulated by a float valve on the feed-water heater.

The generator of unit No. 6 (see headpiece on this page) is of standard construction, star-connected, being designed to deliver three-phase 60-cycle current at 12,000 volts. The speed is 1200 r.p.m. and the rating 35,300 kv.-a., or 30,000 kw. at 85 per cent. power factor.

For cooling the generator windings, a motor-driven blower has been installed with capacity to deliver 120,000 cu.ft. of air per minute. The air-intake passage is equipped with an air washer of suitable capacity, which comprises the usual complement of spray chamber, eliminators and tempering coils to clean, cool and humidify the air. Sufficient steam at low pressure is supplied to the tempering coils to maintain the humidity at the desired point below saturation. The motors driving the blower, circulating pump and economizer fans operate on 440-volt service and have standard remote-control starting equipment. The motors are brought up to speed automatically by a system of accelerating relays and air-break contactor-type circuit-breakers with push-button control.

Unit No. 4 (see headpiece on page 354 and Fig. 3), the second of the new machines to be placed in service, is of a relatively new type of which a striking feature is the compactness of arrangement for a unit of such large capacity. The turbine is of the impulse type. The wheels, arranged in a single casing, increase progressively in diameter from the first to the last stage. Similarly, there is an increase in the length of the blading conforming in a general way to the increase in volume of the steam in its expansion as it passes through the turbine.

Steam is admitted to the annular ring supplying the first-stage nozzles through a single-balanced valve closed by a spring and opened by a cam-actuated lever under the control of the governor. A secondary control valve of similar design supplies steam to one of the intermediate stages of the machine, this valve opening automatically when the load on the unit reaches a certain predetermined capacity. By the new arrangement the numerous admission valves of former designs have been eliminated.

ugal pump, Fig. 5, driven by a 600-hp. induction motor. The speed is 300 r.p.m. and the capacity against an 18-ft. head, 60,000 gal. per min. There are two sets of combined air and condensate pumps, Fig. 6, each set being driven by a 190-hp. turbine running 1500 r.p.m. One set is a stand-by to the other.

The general arrangement of the auxiliaries is somewhat similar to those for unit No. 6. With the combination pump, both air and condensate are withdrawn from the condenser, separate piping connections being provided. The air is discharged with the hurling water to a reservoir from which it escapes into the room, and the condensate is passed through the preheater at the top of the condenser to the feed-water heater. Cross-connections allow either pump to serve the condenser. As the hurling water is constantly recirculated, it requires cooling. For this purpose a surface-type cooler is inserted in the hurling-water reservoir and a certain percentage of the condenser circulating water is passed through the tubes. Arrangements for the supply of

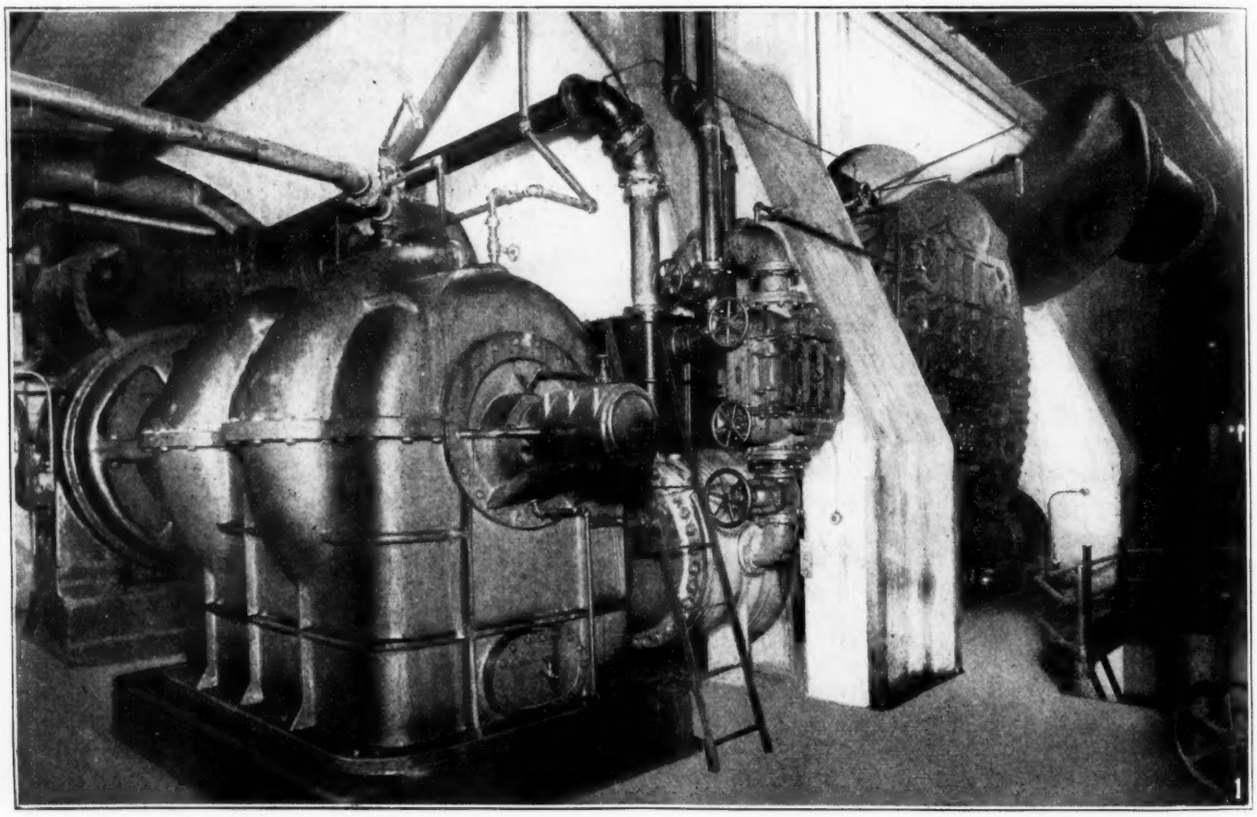


FIG. 1. TWO SURFACE CONDENSERS TO THE RIGHT, EACH CONTAINING 28,000 SQ.FT. OF COOLING SURFACE, AND IN THE FOREGROUND A 60,000-GAL.-PER-MIN. CIRCULATING PUMP FOR UNIT NO. 6

The unit has four main bearings cooled by water from the house service. Bearing oil is supplied under forced circulation at about 20 lb. pressure, by a screw pump geared to the turbine shaft. In starting, use is made of an auxiliary steam pump that is cut out of service when the unit is up to speed.

The turbine of unit No. 4 is served by a two-pass surface condenser, Fig. 4, containing 56,000 sq.ft. of surface. The condenser is rigidly connected to the turbine exhaust, the necessary freedom for expansion being provided by supporting the condenser on springs. Cooling water is circulated by a bi-rotor 48-in. centrif-

makeup water to the condenser are as previously described for unit No. 6.

The electrical generator of unit No. 4 is a three-phase 25-cycle machine rated to deliver 35,000 kw. at unity power factor, the speed being 1500 r.p.m. A 250-volt 110-kw. shunt-wound exciter is mounted at the end of the generator shaft. Cooling air for the main generator is washed, cooled and humidified as in the case of the other unit, but the air is forced through the machine by the action of the generator rotor, no independent blower being used. The heated air from the generators is discharged to the boiler-room base-

ment, whence it finds its way to the boiler furnaces. This saving of heat that otherwise would be wasted is in line with modern tendencies.

In general the new boiler installations are similar to the equipment installed for unit No. 3, which, as previously mentioned, was described in the June 20, 1916, issue of *Power*. May 16 and 30, 1916, issues dealt with the condenser-circulating and the coal-handling system.

As a brief summary it may be stated that the steam-generating equipment for each of the new units consists of five cross-drum water-tube boilers generating steam at 240 lb. gage and 200 deg. F. superheat. Each boiler contains 12,200 sq.ft. of steam-making surface, giving 61,000 sq.ft. for the unit. Two chain grates having a total active area of 304 sq.ft., bearing a ratio to the steam-making surface of 1 to 40, are placed under each boiler. The furnace is of the expanding type with a tile roof and the first pass at the rear. Each boiler is connected to an economizer containing 6450 sq.ft. of tube surface and equipped with a motor-driven induced-draft fan capable of handling 90,000 cu.ft. of hot gases per minute. Five boilers are served by a self-supporting steel stack 18 ft. in diameter and 250 ft. in height above the boiler-room floor, the base of the stack resting on a steel structure at a level 66 ft. above the boiler-room floor. Two turbine-driven boiler-feed pumps are installed for each unit, the capacity of each pump being 900 gal. per minute.

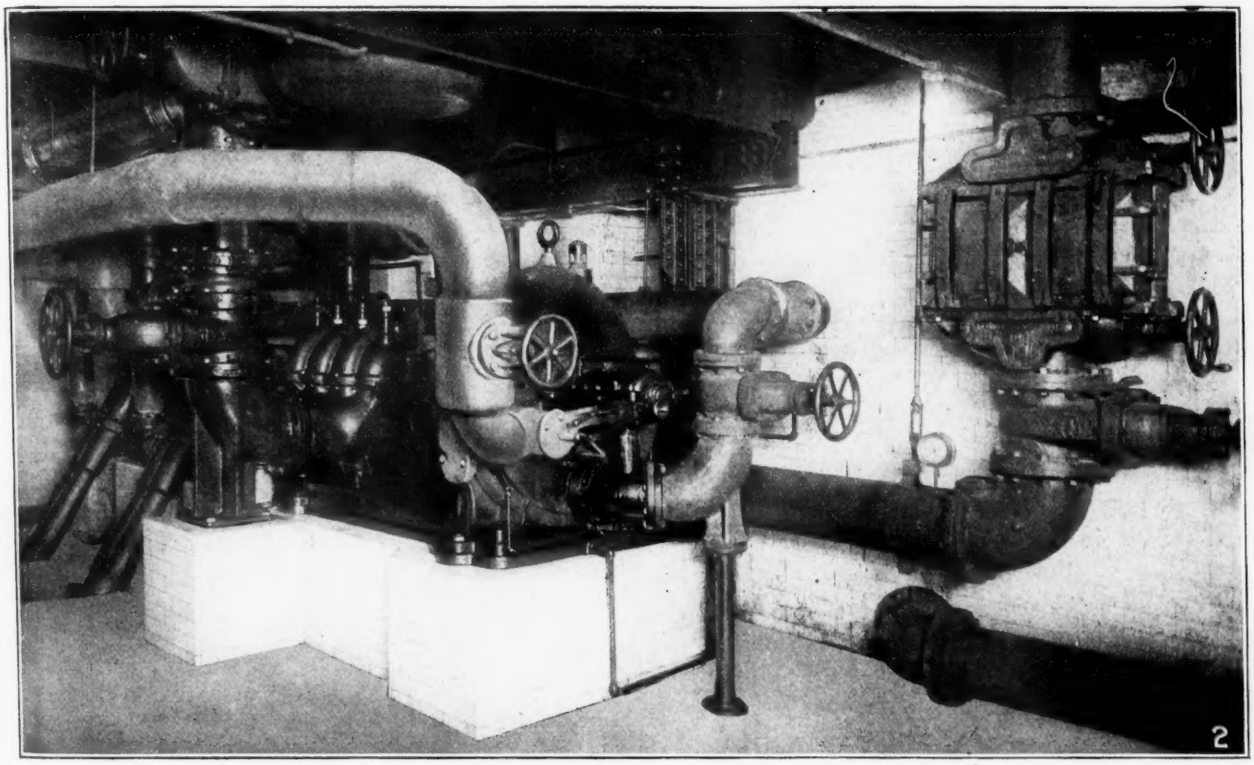


FIG. 2. TURBINE-DRIVEN CONDENSATE AND HYDRAULIC AIR PUMP FOR UNIT NO. 6

The electrical system follows the standard practice of the company of simple two-bus arrangement. The alternators are star-connected with the neutral end of each phase brought outside of the machine for the purpose of connecting in current transformers used in connection with protective relays. Beyond the current transformers the three leads are brought together to form the neutral point of the star, from which connection to the neutral bus is made through an oil switch.

For each unit the stator leads consist of two cables per phase. In the case of unit No. 4 each cable has 1,500,000 cir.mils cross-section, and the cables of No. 6, the 60-cycle generator, have 1,250,000 cir.mils. cross-section each. The leads are lead-covered and are carried within barrier structures similar to the busbar construction. The lead sheath is grounded solidly at the generator end and through a resistance of about ten ohms at the other end.

On each unit is used the company's standard system of protection for the generator. It consists of balanced relays that balance the current going through the neutral end of each phase winding against the current flowing in that same phase lead at the oil-switch end of the connection. In case of a fault in the generator windings or leads between the windings and the oil switches, which include in the 25-cycle units the generator reactor coils, these relays operate and instantly open the main oil switch, the neutral oil switch if it is closed, the field switch, and in the case of the 60-cycle machine, the switch on the motor driving the generator's ventilating blower. The opening circuit of the field switch is connected in series with contacts on the main oil-switch mechanism so as to insure against the opening of the field before the alternator's stator circuit has been opened.

For the preceding information on steam equipment, *Power* is indebted to Sargent & Lundy, consulting engineers for the Commonwealth Edison Co. The electrical data came from the electrical department of the company.

PRINCIPAL DATA ON EQUIPMENT OF NEW UNITS

Turbo-Generator No. 4

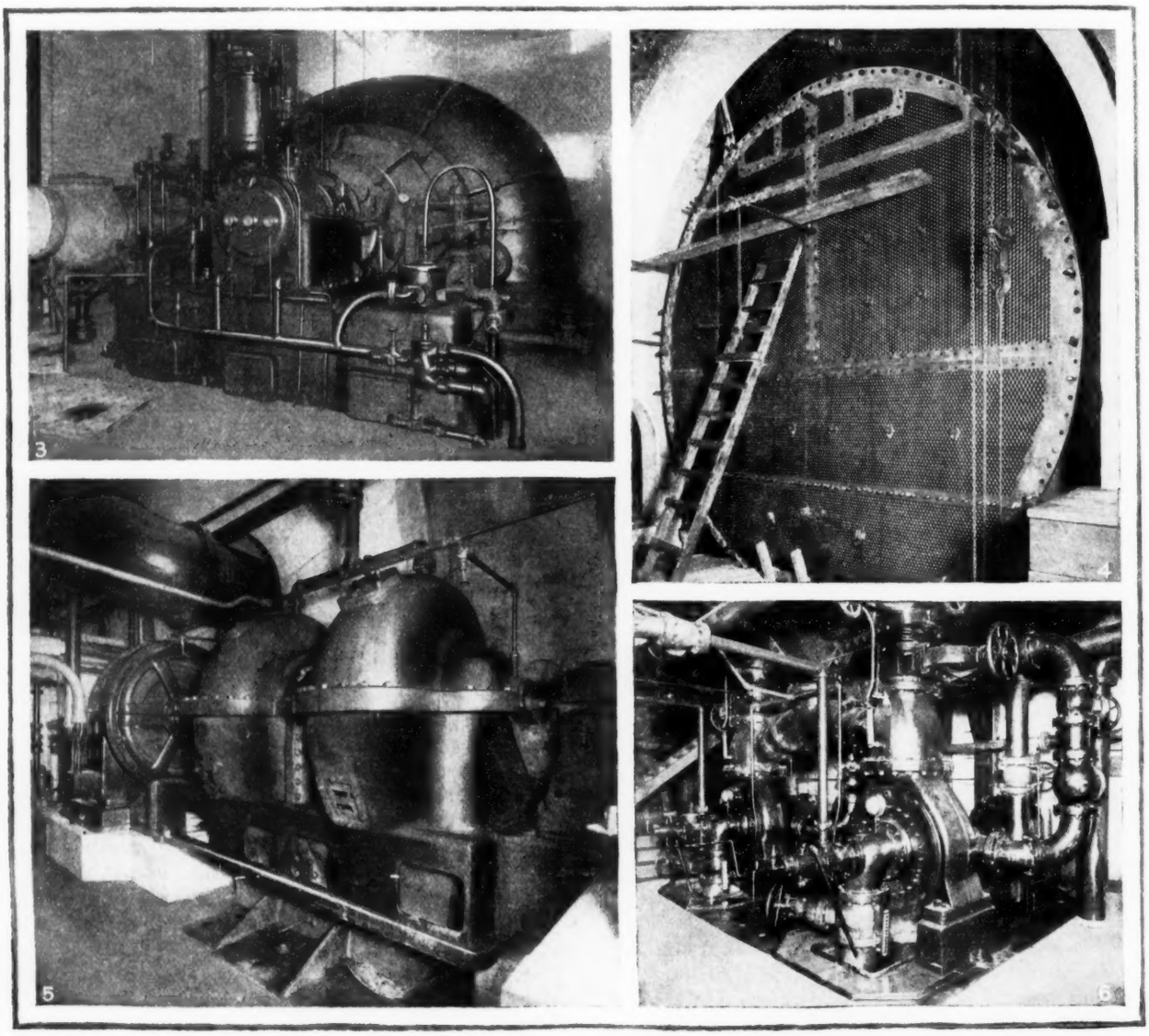
Turbine	General Electric single-cylinder horizontal impulse type
Capacity, kw	35,000
Speed, r.p.m	1,500
Generator	Three-phase, 25-cycle, 9,000 volts
Capacity, unity power factor, kw	35,000
Exciter, direct-connected, capacity, kw	95
Air for cooling, cu.ft. per min	60,000
Unit:	
Length, over-all, ft	50
Width, ft.-in	19–10
Floor space per kw. (35,000 kw.), sq.ft	0.028
Condenser	Two-pass surface, Wheeler Condenser and Engineering Co.
Number of tubes, including preheater	12,959
Tube diameter, o. d., in	1
Length between heads, ft	16.5
Surface, sq.ft	56,000
Surface per kw. (35,000 kw.)	1.6
Circulating pump	Wheeler bi-rotor
Capacity, 18-ft. head, gal. per min	60,000
Driven by G.E., 440-volt 3-phase 600-hp. induction motor, speed, r.p.m.	300
Combined air and condensate pumps, two units	Wheeler
Each unit driven by 190-hp. G. E. turbine, r.p.m	1,500
Capacity condensate pump, gal. per min	1,200

Turbo-Generator No 6

Turbine	Westinghouse two-cylinder reaction
Capacity, kw	30,000
Rows of blading, h.-p. element	90
Rows of blading, l.-p. element, single-flow	20
Rows of blading, l.-p. element, 2 double-flow stages, each	16
Speed, r.p.m	1,200
Generator	Three-phase, 60-cycle, 12,000 volts
Capacity, 85 per cent. p.f., kw	30,000
Exciter, direct-connected, shunt-wound, capacity, kw	110
Cooling air, cu.ft. per min	120,000
Unit:	
Length over-all, ft.-in	72-9
Width, ft.-in	19-2
Floor space per kw. (30,000 kw.) sq.ft	0.046
Condenser	Westinghouse surface, two shells
Number of tubes	12,972
Tube diameter, o.d., in	1
Length between heads, ft	16.5
Surface, including preheater, sq.ft	56,000
Surface per kw. (30,000 kw.), sq.ft	1.87
Circulating pump	Westinghouse bi-rotor
Capacity, 18-ft. head, gal. per min	60,000
Driven by Westinghouse 600-hp., 440-volt ind. motor, speed, r.p.m.	350
Air pump	Leblanc, same shaft as condensate pump, two units, each driven by 139-h.p. Westinghouse turbine
Capacity condensate pump, gal. per min	1,200

Boiler Unit for No. 4 or No. 6

Boilers	B. & W. Cross-Drum
Number of boilers to each turbine	5
Tubes per boiler	588
Diameter of tubes, in	4
Length of tubes, ft	18
Steam-making surface per boiler, sq.ft	12,200
Pressure at turbine throttle, lb. gage	230
Superheat at turbine throttle, deg. F	200
Temperature of steam at throttle, deg. F	600
Nominal capacity each boiler, lb. steam per hour	85,000
Size steam main to turbine, outside diameter, in	20
Stoker, two per boiler	B. & W. Chain Grate
Active area two stokers, sq.ft	304.6
Ratio grate area to steam-making surface	1 to 40
Pumps, two boiler-feed per unit	Worthington, turbine-driven three-stage
Capacity, lb. per hour	450,000
Feed-water heater	Open type, Warren Webster
Capacity from 60-150 deg. F., lb. per hour	400,000
Economizer, one per boiler	B. F. Sturtevant
Number of tubes	456
Length of tubes, ft	12
Heating surface in tubes, sq.ft	6,450
Fans, induced-draft	B. F. Sturtevant multivane
Capacity, cu.ft. hot gases per min	90,000
Stack	Steel self-supporting
Height above boiler-room floor, ft	250
Diameter inside, ft	18



FIGS. 3 TO 6. TURBINE AND CONDENSER EQUIPMENT OF UNIT NO. 4

Fig. 3—End view of turbine. Fig. 4—End view of condenser with cover plate removed. Fig. 5—Bi-rotor circulating pump. Fig. 6—Two sets, combined air and condensate pumps.

The Selection of Ammonia Condensers

By M. A. SALLER

Some suggestions are made to assist the engineer in getting acquainted with the chief factors that should guide him in the selection of condensers for the refrigerating plant.

IN THE following it is not the intention of the writer to go into a thorough analysis of the advantages and disadvantages of the various types of condensers for refrigeration plants, but merely to suggest the chief points with which the engineer should acquaint himself before selecting a particular type.

Condensers for use in compression or absorption plants are made in four general types: Atmospheric, or open-air type; double-pipe, or closed condensers; straight-tube surface condensers; submerged condensers.

In the atmospheric, or open-air condenser, a number of coils or passes are employed through which the ammonia gas flows, the cold cooling water trickling down over the outside of the pipes from a trough or distributor above, to a collecting pan or basin below.

The double-pipe condenser, as the name implies, consists of a double set of pipes, one located inside the other, the ammonia passing through the inner tube, while the cooling water is passed through the coil surrounding it.

The straight-tube surface condenser is designed along the same lines as the surface condenser regularly used in steam-engine and turbine practice.

The submerged condenser consists of ammonia-carrying coils submerged in a tank through which the cooling water is circulated.

Selection of Type Rests Largely on Conditions

The decision as to which of the four types should be used rests largely on the conditions surrounding the plant, its method of operation and the amount of money available. That the operator may have suggested to him all the various factors, the different points for and against each type are briefly outlined. Present-day practice in refrigerating-plant service tends toward the use of the atmospheric and double-pipe types in the great majority of cases, the outstanding feature of the atmospheric type being its simplicity and low first cost, while the double-pipe condenser is often preferred because of its high efficiency.

One of the worst features of the double-pipe condenser is that if a water containing an appreciable quantity of foreign matter or scale-forming impurities is used for cooling purposes, it will quickly collect in the pipe and cause a coating of the surfaces which will greatly reduce the efficiency and finally cause complete stoppage of the pipe. It should be remembered that scale in a double-pipe condenser is a more serious matter than in the atmospheric type. With the exposed surface of the atmospheric condenser any deposit which forms will be quickly noticed and may be readily scraped off even while the condenser is in operation, while in the double-pipe condenser the coating of scale can be detected only by shutting down the plant for examination or by noting a reduction in the efficiency of the plant, following which the unit must be cut out of service for cleaning.

A scale formation of the same thickness is also a more serious matter in the double-pipe condenser than in the atmospheric type. In the latter case the scale gathers on the outer surface of the tubes and really might be said to increase the area of the cooling surface, though probably not sufficiently to counterbalance the insulating properties of the scale.

Scale in the double-pipe condenser forms on the outer surface of the inner pipe and materially decreases the heat-transmission efficiency; also, it forms on the inner surface of the outer pipe and reduces the sectional area of the water passage.

Other Disadvantages of Double-Pipe Condenser

The decrease in the transverse area of the water-carrying tubes caused by scale in a double-pipe condenser also requires an increase in power to circulate the water through it, and in the same proportion the flow of water decreases if extra pressure is not applied. In the atmospheric condenser, where the cooling water merely flows over the coils by gravity, the quantity or distribution of the water is not affected by scale formation. As in cooling-tower practice, advantage is taken in the atmospheric condenser of the reduction in temperature resulting from the evaporation of some of the water which is cooled by the natural air currents and the outside temperature prevailing. This slight advantage is lost with the double-pipe condenser.

It should also be considered that the matter of ammonia leaks in the double-pipe condenser operates to its disadvantage. Because of the great affinity of anhydrous ammonia for water, a leak in a double-pipe condenser may continue for a long time, the ammonia being absorbed by the circulating water, without detection. The double-pipe condenser requires extra attention when shutting down the plant, especially in winter. Should the water remaining in the closed circuit of the double-pipe condenser be frozen, the rupture of one or more of the pipes or fittings is likely to occur.

In first cost the atmospheric condenser has an advantage over the double-pipe condenser because only a single coil of pipe, with much simpler connections, is required with a distributing and collecting trough, as compared to the double set of coils and special fittings usually found in the double pipe. As a general rule it can be figured that the first cost of the double-pipe condenser runs from three to four times the cost of the atmospheric type, figured on the basis of square feet of cooling surface.

In the matter of compactness, however, the double-pipe condenser has the advantage because, due to its higher efficiency, a small condenser will do the same work as a larger atmospheric condenser. The double-pipe condenser can also be installed indoors, while the atmospheric type must be installed outdoors or in a room separated from other machinery because of the presence of moisture. By reason of its compactness and

freedom from moisture and water splashing, the double-pipe condenser can be located close to the ice machine, with a saving in cost of pipe lines, therefore this type is frequently used in small plants.

Where the cooling water is to be used over again for other purposes under pressure, the double-pipe condenser also possesses an advantage, in that the cooling water can be taken from the condenser under pressure to any other point of use, whereas in the atmospheric type all the pressure is dissipated when the water is exposed to the atmosphere. Where an unlimited supply of cheap water under pressure is available, the double-tube condenser can also be used to advantage and can frequently be installed in the lower portion of the building, saving the investment in an extra set of pumps which might be required to force the water up to an atmospheric condenser installed up high on the roof. In congested localities, such as in the heart of cities, the water and moisture passed out to the atmosphere by the open type of condenser is often objectionable, and in these cases the double type offers a nice solution of the problem.

High Efficiency of Double-Tube Type

Given favorable operating conditions—good clean cooling water, clean pipes and high velocity of circulating water—a high efficiency can be secured from the double-tube condenser. Giving the double-tube condenser the benefit of these favorable conditions, the comparison of the two types expressed in number of B.t.u. exchanged per square foot of cooling surface per hour can be stated as: Atmospheric type, 60 B.t.u. per deg. difference; double-tube type, 100 B.t.u. per deg. difference.

Because of this theoretically higher efficiency it should be possible to do the work with the double-tube condenser with 40 per cent. less cooling surface than in an atmospheric condenser; but when it is considered that the cooling surface in the double-tube type costs about 300 per cent. more than the atmospheric, this apparent advantage must be qualified. It should also be remembered that this theoretical efficiency will not always be encountered because of the unfavorableness of operating conditions.

Summed up, it would appear that the atmospheric condenser is the type that can be used to advantage in the average plant where no restrictions are encountered as to roof space, building congestion, etc., though the double type appears to be the most attractive where good cooling water is available or where the condenser can advantageously be located inside the building or near the compressor.

As to the straight-tube surface condenser, this is not so generally used on account of the expensive construction involved as against the atmospheric type, because it is subject to the same troubles from "scaly" water as the double-tube type, and because trouble is usually experienced in maintaining tight connections at the tube heads, the ammonia leakage being quite considerable unless constant attention is paid to keeping the tubes tight.

The submerged type of condenser is very cheap, comprising merely a tank and some ammonia coils, though it is not desirable for large-plant work because of the large size of tank required and the weight of the large volume of water it carries. The matter of detecting leakage is also unfavorable. In a condenser of this type it is also often necessary to install stirring apparatus to insure proper circulation.

Fyrox Moving West

The present condition of stress makes the public more susceptible to the exploitation of nostrums that are supposed to save a large percentage of coal. Purveyors of these preparations are alive to the situation. Our old friend "Fyrox," so active in the East last summer, and of which *Power* had something to say on page 56 of the July 10, 1917, issue, recently bobbed up in Detroit. As may be remembered, the compound is in powder form put up in one-pound boxes which sell for one dollar. A box of the compound is dissolved in 8 to 10 gal. of water, depending upon the size of coal burned, and the resulting solution is sprinkled over the coal. According to the directions given this amount is sufficient to treat two tons of coal. It is claimed that ordinarily two tons of treated coal will last as long as three tons of the untreated, thus saving one-third of the coal bill.

An inquisitive citizen of Detroit brought a box of the preparation to J. C. McCabe, director of the Department of Safety Engineering, requesting an opinion on its merits. An analysis by the Detroit Testing Laboratory showed the following ingredients:

	Per Cent.
Moisture	0.51
Common salt with trace of potassium chloride	89.93
Potassium permanganate	0.23
Potassium chlorate	0.88
Carbon	2.45
Sugar	6.00
	100.00

In other words, nearly nine-tenths of the preparation is common salt, and the cost of one pound of the mixture at the present high prices is about six cents. Apparently, if there were any advantage in using such a compound, it would be considerably cheaper to patronize the local stores.

When sprinkled on a hot fire salt produces a highly colored flame, but does not add to the heat value of the fuel. If used in sufficient quantity, it would tend to slow up combustion and eventually extinguish the fire. Less coal would be burned and less heat would be generated.

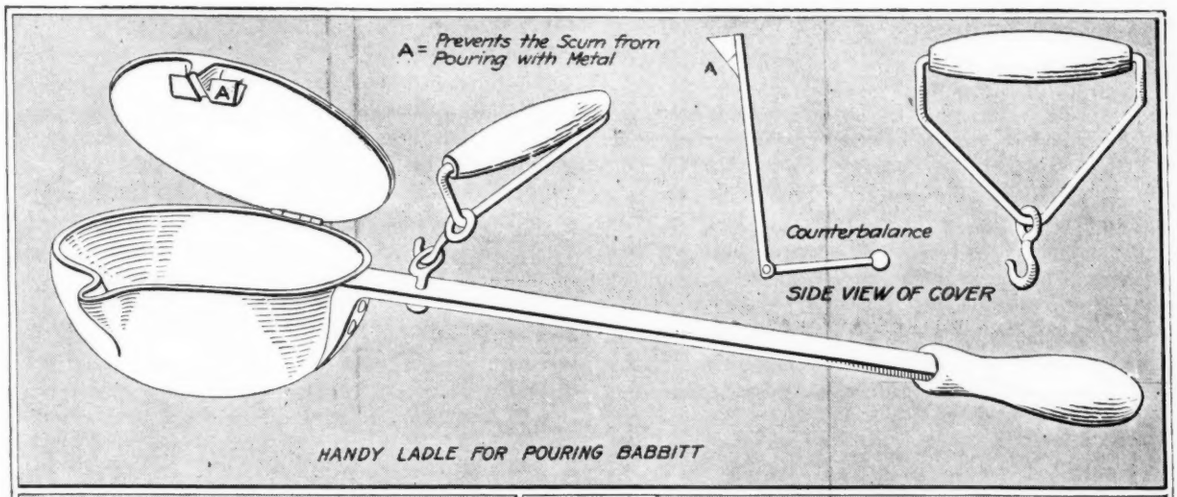
It will be noticed that one pound of Fyrox is used to 4000 lb. of coal, the proportion being 0.025 per cent. It should be evident that any benefit, or for that matter injury, to combustion must be negligible.

Calorimetric tests on two identical samples of coal, one without and the other with 400 times the amount of Fyrox specified, gave 11,517 and 11,767 B.t.u. respectively. The second test was made with a slightly heavier fusion wire, which would mean a little more heat in the calorimeter. The usual variation between readings is about 2 per cent., or in the present case, say, 200 B.t.u., so that for all practical purposes the heat from each sample of coal was identical.

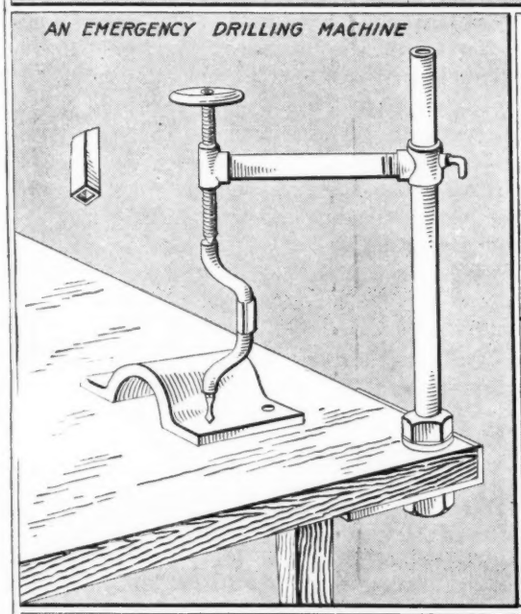
If it is the psychological effect that is desired, something that will influence the fireman to improve his methods and to watch the fire more carefully than usual, why not use plain water and give it a trade name to conceal its identity? The results would be equivalent and the cost much less.

From an Engineer's Notebook

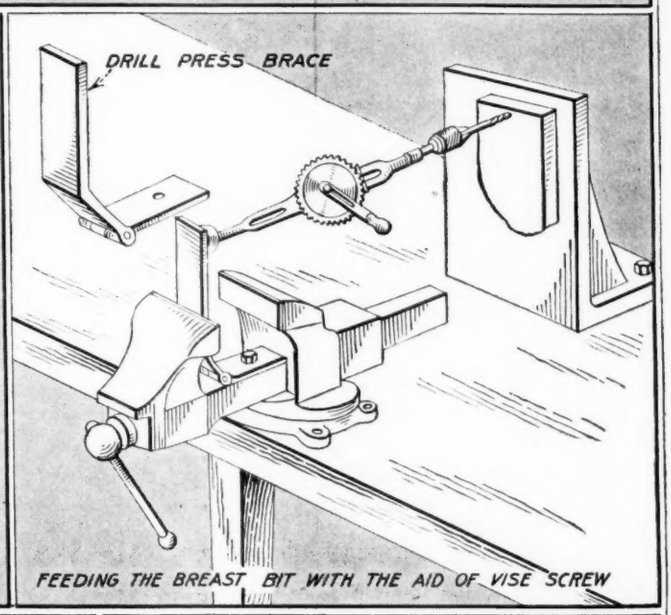
By M. P. Bertrande



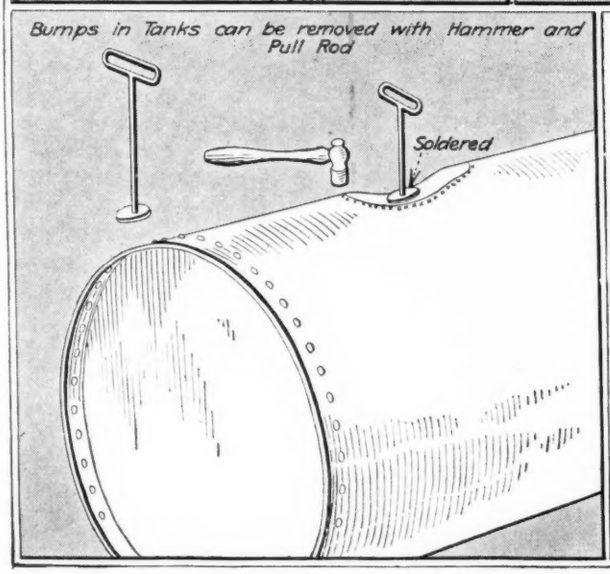
HANDY LADLE FOR POURING BABBITT

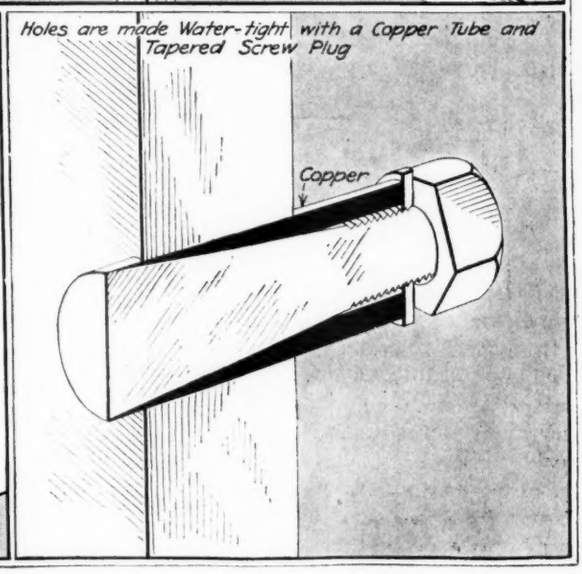


AN EMERGENCY DRILLING MACHINE



FEEDING THE BREAST BIT WITH THE AID OF VISE SCREW





The Electrical Study Course—Commutation

The process involved in the armature coils under commutation is explained, and one of the methods that may be used to assist in commutating the current is pointed out.

IN FIG. 1 the lines of force pass from the N pole into the armature core between points *B* and *D;* likewise under the S pole the magnetic flux passes from the armature core into the S pole between points *A* and *C*. It is only between these points that the armature conductors will be cutting the lines of force and therefore generating voltage, when the armature is revolved. Between points *A* and *B* on the left-hand side of the armature and *C* and *D* on the right-hand side, the conductors are outside of the magnetic field and are not cutting the latter; therefore do not produce any voltage. The space between the polepieces where the conductors do not cut any line of force is called the neutral point or neutral zone. It is always at this point that the brushes must be located on the commutator, because if they are very far off the neutral, serious sparking will result.

In general it is possible to shift the brushes slightly ahead of the neutral, that is, in the direction that the armature is turning, or to shift them slightly back of the neutral, against the direction of rotation, without seriously interfering with the operation of the machine. In some cases the brushes can be shifted slightly ahead or back of the neutral with beneficial effect upon the operation of the machine. However, this is a subject to be considered in a later lesson.

We have already seen in a previous lesson how a ring divided into two parts acts to cause an alternating current generated in a coil revolving between the poles of a magnet to flow in one direction in the external circuit. It will be recalled that, although the current was caused to flow in one direction, the current was of a pulsating nature; that is, flowed in waves. Where a number of coils are connected to a commutator, as in Fig. 1, the current not only flows in one direction in the external circuit, but also is maintained at a constant value. This will be seen by considering what takes place at the brushes as the armature revolves.

In Fig. 2 the armature is shown after it has been revolved one segment from the position shown in Fig. 1. In Fig. 2 coil *k*, which was under the N pole in Fig. 1, has moved out from under the pole and into the neutral zone, while coil *j*, which is in the neutral zone in Fig. 1, has moved in under the N pole, thus maintaining the same number of active conductors under this pole. The same thing has happened under the S pole, where coil *g*, which is under this pole in Fig. 1, has moved out into the neutral zone and coil *h* has come in under the pole, thus maintaining the number of active conductors under this pole constant and consequently maintaining the voltage at the brushes constant, which in turn will cause a current of constant value to flow in an external circuit *L* of constant resistance. This is the process that is going on all the time in the armature as long as it is revolved. As fast as one armature coil moves out from under a polepiece, another moves in to take its place, thus maintaining the number of active coils on the armature constant.

The process that takes place around the coils under commutation, that is, the coils in the neutral zone, is one of the most complicated operations in the machine. In Fig. 1 the current in coil *l* is flowing up through the plane of the paper and to the positive brush. At the negative brush the current is flowing from segment *c* to coil *m* and down through the plane of the paper. In Fig. 2 the current in coil *l* is flowing down through the plane of the paper and to segment *e* and then to the positive brush, and at the negative brush the current is flowing in through segment *b* and to coil *m*, up through the plane of the paper. From this it is seen that the direction of the current in coils *l* and *m* is reversed in Fig. 2 from that of Fig. 1. In other words, when the armature revolves through an arc equal to the width of a commutator segment, that is, causes one segment to move out from under a brush and another to move in, the current in a coil connected to the segments that the brushes rests on is reversed.

In changing from the condition in Fig. 1 to that in Fig. 2, there was a period when coils *l* and *m* were short-circuited; this is shown in Fig. 3. In this case the positive brush rests on segments *d* and *e* and the negative brush on segments *b* and *c*. When the brushes are in this position, as far as the circuits in the armature are concerned there need not be any current flowing in coils *l* and *m*, since as shown in the figure, the current to the positive brush can flow directly from coils *h* and *k* without flowing through coil *l*. Likewise at the negative brush, the current is from the brush to coils *g* and *j* without passing through coil *m*. In other words, coils *m* and *l* are shunted out of circuit, until the brushes move onto segments *b* and *e*, as in Fig. 2, where the current must flow in an opposite direction, in coils *l* and *m*, to that in Fig. 1.

The foregoing might be easily accomplished if it were not for the property of self-induction, which is present in every electrical circuit when the current is changing in value. It was shown in the lesson in the Dec. 4 issue, that when the current is increasing in value in a conductor, the conductors cut the line of force set up by the current and induce a voltage that tends to prevent the current from increasing in value, and when the current is decreasing in value, the conductors cut the line of force in a direction which creates a voltage that tends to keep the current flowing in the circuit. In other words, the effect of induction is to oppose any change in the value of the current in the circuit.

Let us see what the result of self-induction is upon the armature coils under commutation, such as coils *l* and *m* in the figures. Start with Fig. 1 and consider only the positive brush. The brush moves off segment *d* onto segment *e* bridging across the insulation between the two segments, as in Fig. 3. If it were not for the induction of the coil, there would be no reason for the current flowing in coil *l*, Fig. 3, but when the coil is short-circuited and the current starts to decrease, it is prevented from doing so by induction and for a short period must continue to flow through the coil into seg-

ment *d*. If this continues until segment *d* moves out from under the brush and segment *e* moves in, as in Fig. 2, then the current must not only cease flowing from coil *l* to segment *d*, but also reverse its direction and build up to full value in the opposite direction, as in Fig. 2. In the latter case induction again tends to prevent the current from building up in the opposite direction. The result of this is, if some means, which will be considered later, is not employed to make the current reverse in the coil under commutation in the time required for the brush to pass from one segment to another, severe sparking at the brushes will take place. This is caused by the current not being able to reverse in the coil, in the time that the brush passes from one segment to another, and follows the brush across the insulation between the segments, similar to the way the spark is produced in a make-and-break ignition system on a gas engine. Another thing is that as segment *d* moves out from under the brush, the contact between the brush is getting smaller all the time until the brush leaves the segment. If considerable current is kept flowing from the coil under commutation into the segment that the brush is leaving, such as coil *l* to segment *d*, Fig. 3, it may increase the temperature of the trailing corner of the brush to the point where it will glow.

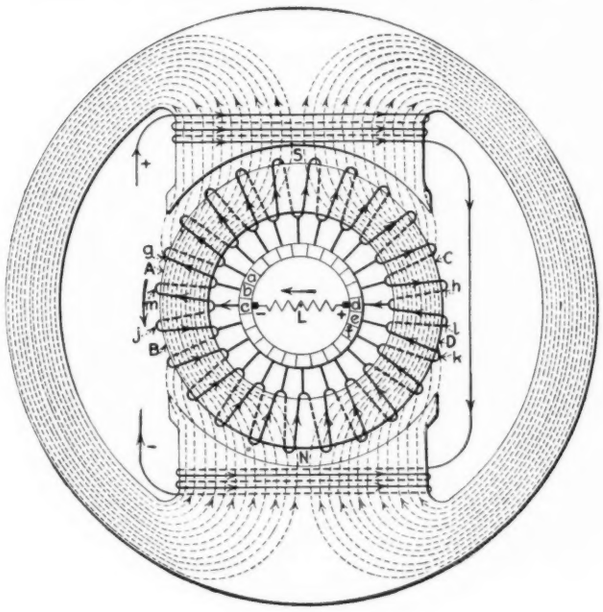


FIG. 1

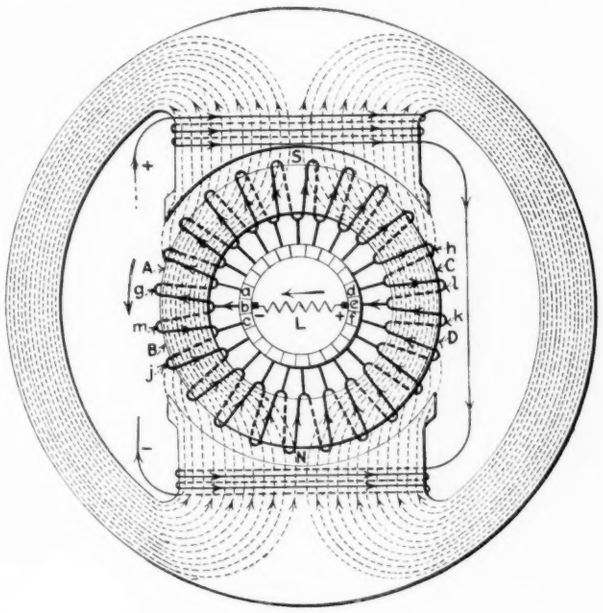


FIG. 2

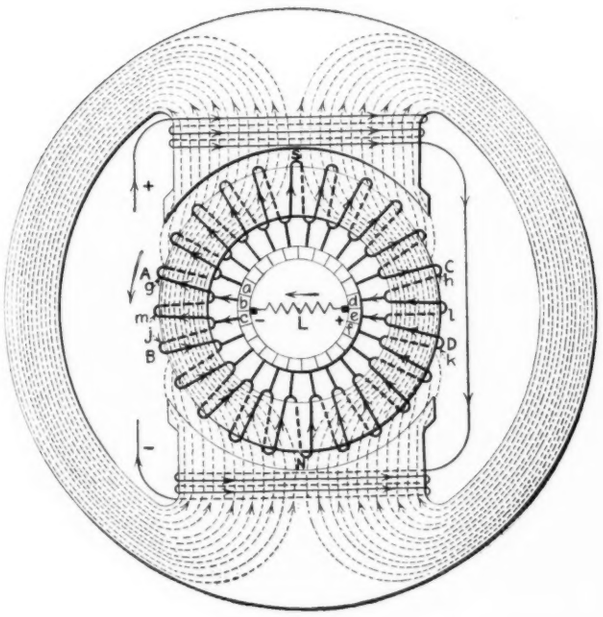


FIG. 3

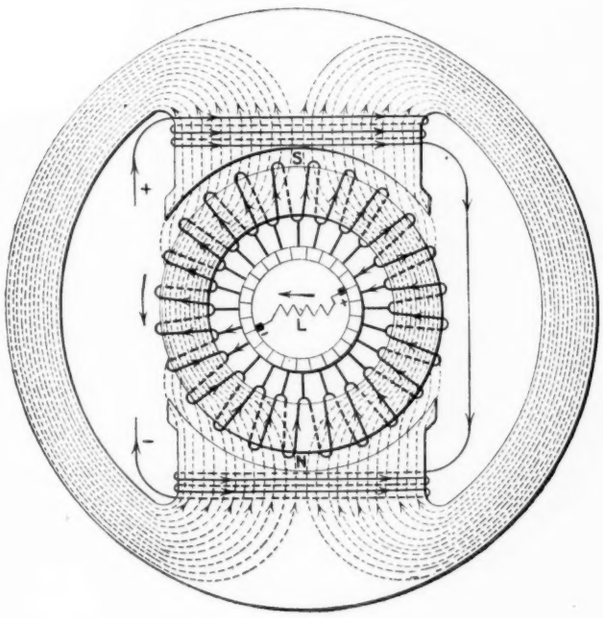


FIG. 4

FIGS. 1 TO 4. DIAGRAMMATICAL REPRESENTATION OF A DIRECT-CURRENT GENERATOR

The time during which the current must decrease from full value to zero and build up to full value in the opposite direction is very small. For example, assume that the armature in the figure is revolving at 1500 r.p.m., which is not an excessive speed. Since there are 24 segments in the commutator, $24 \times 1500 =$ 36,000 segments pass each brush per minute, or 600 seg-

ments per second. We have just seen that each time a segment passes a brush, the current reverses in a coil. Therefore, when a two-pole armature having 24 segments revolves at 1500 r.p.m., the current must reverse in the coil under commutation in $\frac{1}{600}$ part of a second. From this it is evident that it may be a somewhat difficult proposition to make the current properly reverse in the coil in such a short period.

At the positive brush the current is flowing up through the coil under commutation and must be reversed and caused to flow down, each time that a segment moves out from under the brush and another one moves in. What would help to reverse the current would be an electromotive force induced in the coil opposite to the direction that the current is flowing in the coil under commutation; that is, if the current is up through the plane of the paper, the voltage will have to be downward to assist in changing the direction of the current. In the figure all the conductors under the S pole have an electromotive force induced in them down through the plane of the paper. Therefore, if the brushes are shifted so that the positive brush will come under the tip of the S pole, as in Fig. 4, the coil under

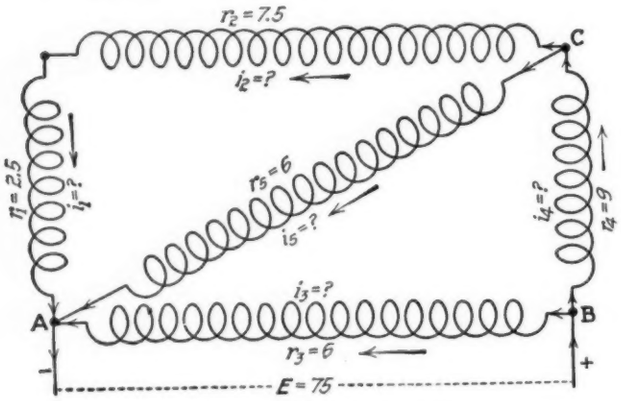


FIG. 5. COMPLEX CIRCUIT

commutation will have a voltage induced in it that is opposite to the flow of the current in the coil. When the brushes are properly located, they will be in a position where the voltage generated in the coil will be just sufficient to reverse the current during the period of commutation.

The foregoing is one way to obtain sparkless commutation and was the one usually relied upon in the early type of machines, but by improvement in design it has become possible to build generators and motors that will operate over their entire range from no load to full load with the brushes located exactly between the pole-pieces without sparking. Further consideration will be given this subject in later lessons. It will be noted that the brushes are shifted in the direction in which the armature is revolving. However, this is true only of a generator.

When we consider the electric motor, it will be found that the brushes must be shifted against the direction of rotation, to assist in reversing the current in the coil under commutation.

In Fig. 5 is given the layout of the problem given in the last lesson, and it is worked out in a manner similar to the one solved in that lesson. Here we have two circuits, a simple one from B through $r_3 = 6$ ohms to A, and a second, a complex circuit, from B through $r_4 = 9$ ohms to C; at this point the circuit divides, one part going through $r_5 = 6$ ohms and the other through $r_2 = 7.5$ ohms in series with $r_1 = 2.5$ ohms to A. It is evident that the simple circuit r_3 is in parallel with the complex circuit just described. In the complex circuit r_5 is in parallel with r_1 and r_2 in series. Therefore, if we represent the joint resistance of this part of the circuit by R', then

$$R' = \frac{1}{\frac{1}{r_1 + r_2} + \frac{1}{r_5}} = \frac{1}{\frac{1}{2.5 + 7.5} + \frac{1}{6}} = \frac{1}{\frac{1}{10} + \frac{1}{6}} = \frac{1}{\frac{8}{30}}$$

$$= \frac{30}{8} = 3.75 \text{ ohms}$$

R' is in series with r_4, hence the resistance of the complex circuit is $R'' = R' + r_4 = 3.75 + 9 = 12.75$ ohms. Then the joint resistance of the total circuit is

$$R = \frac{1}{\frac{1}{R''} + \frac{1}{r_3}} = \frac{1}{\frac{1}{12.75} + \frac{1}{6}} = \frac{1}{\frac{18.75}{76.5}} = \frac{76.5}{18.75} = 4.08 \text{ ohms}$$

Then the total current $I = \frac{E}{R} = \frac{75}{4.08} = 18.38$ amperes.

Since full pressure is applied across r_3, $i_3 = \frac{E}{r_3} = \frac{75}{6} = 12.5$ amperes. Full voltage is also applied across the complex circuit R'', hence, in this circuit the current $I' = \frac{E}{R''} = \frac{75}{12.75}$ $= 5.88$ amperes. All this current flows through r_4, therefore, $i_4 = I' = 5.88$ amperes. After the current passes through r_4, it divides at C, part of it going through r_5 and part going through r_1 and r_2 in series. The voltage drop across r_4 is $e_4 = r_4 i_4 = 9 \times 5.88 = 52.92$ volts. $E' = E - e_4 = 75 - 52.92 = 22.08$ volts available between C and A, from which $i_5 = \frac{E'}{r_5} = \frac{22.08}{6} = 3.68$ amperes, and $i_1 = i_2 = \frac{E'}{r_1 + r_2} = \frac{22.08}{2.5 + 7.5} = 2.2$ amperes. The sum of i_5 and i_1 or i_2 is $3.68 + 2.2 = 5.88$ amperes, which checks up with i_4 the current flowing in r_4. This is as it should be.

In Fig. 1 if the resistance of each half of the armature winding from the positive brush around to the negative brush is 0.5 ohm, and there is connected between the brushes a resistance $L = 4.75$ ohms, what current will flow in the external circuit and in each half of the armature winding when 150 volts is being generated in the winding? Also, what will be the value of the volts across the brushes when the external circuit is connected?

An owner of land joining a stream above an existing dam loses all right to enjoin a raising of the dam, although that causes overflow of his lands, where no objection was made while the new structure was being constructed, and he maintained suits to collect damages for the injury done his property, without then seeking to enjoin further maintenance of the dam at its increased height. In addition to laying down this rule of law in the case of Holcomb vs. Alpena Power Co., 164 Northwestern Reporter, 470, lately, the Michigan Supreme Court also decided that where land is permanently flooded by a dam; the owner's damages should be computed in full in one suit on the basis of the excess of value of the land unflooded above its value as flooded.

Possible Saving in Avoiding Leaks in Boiler Setting

By J. M. AARONS

Some well-known truths are pointed out. Air leakage through boiler settings, due to cracked settings and porous bricks, can be reduced to a minimum by coating the brickwork. The present coal situation is bringing home the facts set forth.

SUPPOSE that 150,000,000 tons of coal could be deposited in the bunkers of the coal users of this country during the next twelve months without any effort on the part of either the mines or the railroads. This would mean that the fuel shortage would not only be overcome, but there would be a large surplus for export. This 150,000,000 tons is the estimated amount annually wasted by the coal users of this country, and the fuel shortage may therefore be charged directly to waste.

Engineers throughout the country have for years been pointing out the possibilities of increased efficiency in the boiler room. Generally speaking, little attention has been paid to them. The executive heads of manufacturing concerns do not, as a rule, make a study of their boiler-house conditions. This part of their operation is looked upon as a hot and dirty place. Combustion, as far as they are concerned, consists in starting a fire and shoveling on sufficient coal at intervals to keep up the steam pressure.

Coal Bills Considered Necessary Evils

Coal bills always touch the "sore spot," but they are looked upon more or less as necessary evils—something to kick about on the first of each month and then forget. Until recently, if the coal bill was 15 to 30 per cent. higher than it should be, it was nobody's business as long as the man who "paid the piper" was indifferent. Today things have changed and every pound of coal wasted is a black spot against the one who sanctions it.

How can coal be saved? When it is taken into consideration that a ton of good-grade coal delivered to the plant contains approximately 29,000,000 B.t.u. and that the average plant delivers to the point where power is used only about 555,000 B.t.u., it will be seen that an enormous waste is taking place somewhere. Part of this loss is unavoidable, but a large percentage of it is due to carelessness in operation and to neglect.

By far the greatest waste is caused by the large amount of excess air that is permitted to enter furnaces and boiler settings and to escape up the chimneys, carrying away heat that should be utilized to do useful work. This unnecessary excess air is admitted in two ways—first, through uneven fires which leave part of the grates bare and, second, through pores and cracks in the boiler settings. Loss due to uneven fires is chargeable directly to improper operation. Every fireman knows that to get the greatest capacity out of a boiler the entire grate surface must be covered with burning fuel and that there must be no holes or bare spots, but apparently many do not appreciate that an even fire is necessary if the fuel is to be burned efficiently. If a few simple instructions along this line were given and the firemen were required to follow them, a tremendous saving would be effected.

The loss due to leakage through boiler settings is even more important because it is less easily detected. If a fire is in improper condition, one look into the furnace reveals the fact, but leakage through settings is not so apparent. There is a certain amount of leakage around doors and boiler drums, but most of it filters through what appears to be a solid brick wall. The heating and cooling of the brickwork opens up a large number of small cracks which increase the leakage without giving a setting the appearance of being in bad condition. The leakage through boiler settings reaches greater proportions than is apparent from an inspection of the brickwork and may be as great as one-half of the amount of air supplied for combustion. This represents a large preventable loss, and one which may go on unnoticed because there is no outward indication that it actually exists. Moreover, the loss due to infiltration of air to the boiler settings is not intermittent but represents a continual source of fuel waste from the time the boiler is put in service until it is taken out. In fact, the condition is gradually aggravated, week after week, as the settings become more cracked and porous.

A large plant recently attempted to purchase two 500-hp. boilers. The delivery on this equipment was so far off that a serious problem faced them. The services of an experienced combustion engineer were engaged to see what improvement could be made in the existing plant. Analyses of the flue gas were taken, and readings as low as 2.4 per cent. CO_2 were secured on two of the boilers. This represented an excess air condition of about 800 per cent. Further investigation disclosed large openings in the settings, and open doors into the combustion chamber were admitting sufficient air to absorb practically all the heat liberated by the fuel burned in the furnaces.

Tight Settings Effect Large Coal Saving

With all settings made tight, which required but a few days' work, the new boilers were no longer necessary, and a large saving of coal was effected. Although this is an extreme case of waste, due to air infiltration, it serves to emphasize the necessity for tight settings. In fact, the heat units actually used in the average boiler room when compared to the heat units that can be obtained under proper operating conditions and with tight boiler settings, if put on a dollar and cents comparative basis, are equivalent to paying $5 for only $2.86 worth of coal.

Any handbook or treatise on boiler and furnace efficiency will point out the necessity of keeping the settings tight. The efficiency guarantee of any stoker com-

pany has a clause referring to tight boiler settings that qualifies their guarantee. In spite of all this the boiler settings in 95 per cent. of the plants leak air excessively.

Every crack and crevice represents waste, and every brick and mortar joint, no matter how good it may look, is passing a certain amount of air. Leaky boiler settings not only seriously affect the coal bill, but materially reduce the capacity of the plant. Many manufacturing concerns that are now crippled through lack of steam could sail merrily along with steam to spare, by simply coating the boiler settings.

The capacities of most chimneys are limited and can handle only so much air as they are not usually generously designed. The higher the temperature of the gases entering the chimney the greater the velocity through it. Its duty in all natural-draft installations is to pull the required amount of air through the fuel bed and to carry off the resultant gases of combustion. If cold air is allowed to leak into the settings, it lowers the temperature of the gases, slows up the velocity through the chimney, puts an unnecessary burden on it and cuts down the capacity of the plant.

There are usually two sides to a question, but there is positively but one side to this one. There can be no argument brought to bear against a tight boiler setting. The first step toward economy in the boiler house should be to cover all brick settings and stacks with a suitable air-tight coating. The material of this coating should have sufficient elasticity to expand and contract with the brickwork and also be capable of standing considerable heat and temperature changes and remain plastic for a long period. Above all, it should adhere firmly to the brickwork and not crack or peel off. There are several compounds that meet these requirements. They are cheap, easily applied and present one of the best investments that can be made.

No matter what improvements are contemplated in the boiler house, the settings should be coated. A fortune may be spent on instruments and boiler-house equipment, but the results striven for will still be missed if the boiler settings are leaky. Fuel represents 70 to 80 per cent. of the total cost of power. Is not 3 to 30 per cent. of this amount worth saving?

Unusual Design of Evaporator for Distilling Sea Water

Those who have to deal with the distilling of sea or other water or with evaporation problems of almost any kind will be interested in the design of the Lillie evaporator now being built by the Wheeler Condenser and Engineering Co., of Carteret, N. J. It is, as will be seen from the illustration, a modification of a regular Lillie sextuple-effect sea-water distilling apparatus. Two of these now under construction are to be operated by steam up to 60 lb. gage pressure or at any lower pressure.

The point that will catch the veteran's eye is the employment of four condensers, side by side, as shown in the illustration. This unusual arrangement of condensers permits seven different combinations of operation, as follows:

It may be operated as one single effect or more single effects; it may be operated as one or more double effects with vapors reversible in each; it is possible to operate it as a triple effect, or as two triple effects with vapors reversible in each; it is impossible, of course, to operate it as two quadruple effects, but every effect may be utilized by grouping as one quadruple effect and one double effect, in both of which the vapors are reversible; it may be operated as one vapor reversible quadruple effect with both end effects or either end pair of the section cut out; with one effect at either end cut out, it may be operated as a vapor reversible quintuple effect; lastly, it may be operated as a vapor reversible sextuple effect.

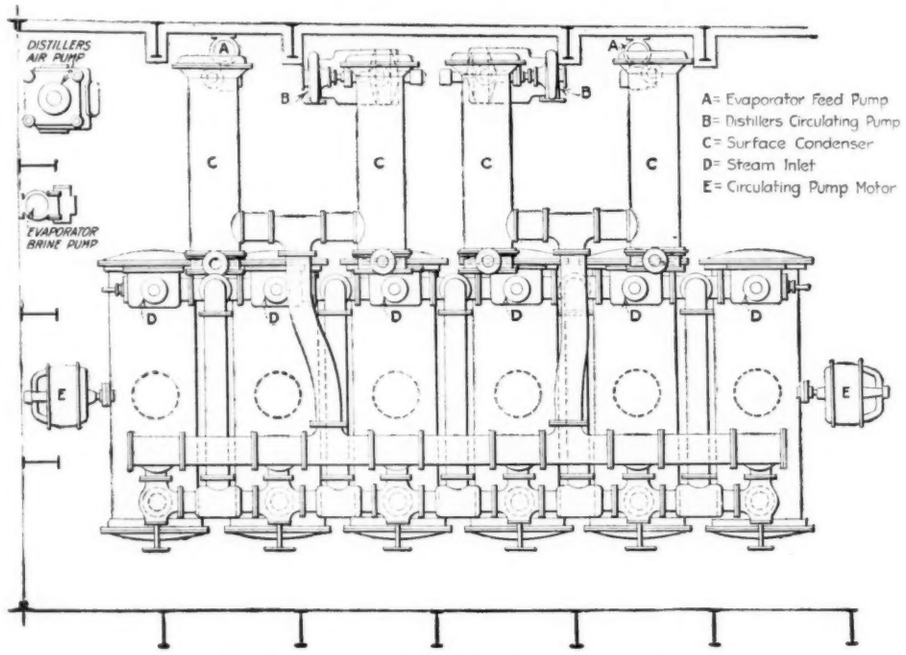


DIAGRAM OF THE LILLIE SEA-WATER EVAPORATOR

It is evident that should a mishap occur at either end, in the middle or anywhere else, there is little danger that this evaporator will be put out of commission entirely.

Useful Conversion Multipliers

	Multiply by		Multiply by
Inches to millimeters	25.4	Miles to kilometers	1.61
Millimeters to inches	0.0394	Grains to grams	0.065
Inches to centimeters	2.54	Grams to grains	15.4
Centimeters to inches	0.394	Grams to ounces	0.35
Inches to meters	0.0254	Ounces to grams	28.35
Meters to inches	39.4	Pounds to grams	453.6
Feet to meters	0.3048	Pounds to kilograms	0.455
Meters to feet	3.281	Kilograms to pounds	2.2
Meters to yards	1.1	Kilograms to ounces	35.3
Yards to meters	0.9144	Kilograms to hundredweight	0.02
Yards to kilometers	0.0009	Hundredweight to kilograms	50.85
Kilometers to yards	1,093.6	Kilograms to tons	0.001
Kilometers to miles	0.62	Tons to kilograms	1,016

—*Graphite.*

Fuel Consumption of Low-Compression Oil Engines

By L. H. MORRISON

THE builders of low-compression oil engines have quite generally adopted the following guarantees of fuel consumed per brake horsepower per hour at various loads: Full load, 0.100 gal.; three-fourths load, 0.110 gal.; half load, 0.125 gal. These performances can be attained in actual service, so long as the wear on the engine is not excessive.

All builders claim that their engines will operate on the heaviest of oils, as well as on other grades up to kerosene. Although any oil engine will work well with a crude oil that contains a considerable percentage of the lighter oils, the service will not be satisfactory if the crude has an asphaltum base. When such oil is used, deposits of carbon and asphaltum occur in the cylinder and cause rapid cutting. The same is true of any fuel oil having an asphaltum base. The wear on the cylinder is particularly heavy if the oil contains dirt and grit.

If a fuel oil is decided upon, it is advisable to purchase a filtered oil, usually sold as "Diesel fuel oil." This will probably cost from one to one and a half cents more per gallon than unfiltered fuel oil, or "boiler oil," but in lessening the wear on the cylinder, reducing the cutting of valves and seats and decreasing trouble in general, it is well worth the difference in cost.

The best all-round fuel is without question a distillate of about 32 deg. Baumé, because it is light enough to burn completely at all loads. Experience has proved that distillate is the proper fuel for any low-compression engine. These remarks apply specifically to asphaltum-base oil; with a paraffin-base oil it seems that any grade of fuel oil or crude may be used successfully.

Amount of Sulphur Should Be Limited

In the purchase of the fuel, limits should be placed on the amount of sulphur in the oil. While one-fifth of one per cent. of sulphur is as much as ought to be allowed, a greater percentage is usually found. One engine builder suggests the following requirements, which have been found satisfactory in connection with his own engines: Specific gravity, not below 26 deg. B.; sulphur, less than 0.5 per cent.; water, less than 0.5 per cent.; coke, not over 3 per cent.; fraction which will distill off below 360 deg. C., at least 60 per cent.; oil to have a heating value of at least 18,500 B.t.u. per lb., and to be free from grit or dirt.

On the basis of brake horsepower, the thermal efficiency at full load will be in the neighborhood of 19 per cent. On the basis of indicated horsepower, disregarding the friction and the power required to run the air compressor, the efficiency will be approximately 23 per cent. If efficiencies much greater than these are guaranteed, it will usually be found that the engine is not of the low-compression type, but belongs to the semi-Diesel class, in which the temperature range allows a greater efficiency to be obtained.

In case the engine drives an industrial load, the best method of drive is by means of a belt. Many engineers show a preference for a clutch coupling connecting the engine shaft to the driven shaft; but with this arrangement it is a hard matter to keep all the bearings in line, and the usual result is rapid wear of the bearings and the clutch friction blocks.

By using a friction belt pulley, the engine can be started under no load and brought up to speed before the load is thrown on. Driving by belt allows the shaft bearings to keep their alignment with greater ease. The wear on the engine and lineshaft bearings is less, and the drive is more flexible.

In an installation in which the engine drives an electric generator, the rotor should, if possible, be placed directly on the engine shaft. In the past it has been the general custom to use a waterwheel or gas-engine type of alternator with self-contained bearings and shaft. This shaft was connected to the engine shaft by a flexible coupling or a flange coupling. Such a method involved at least one extra bearing or was hard to keep aligned. In the later engines an extended shaft and an outboard bearing are generally used. The rotor can be pressed on the shaft extension. Such an installation is more attractive and easier to keep in good shape.

The question often arises as to the possibility of paralleling two alternators driven by low-compression engines. If the engines are of the single-cylinder type, the synchronizing will be more difficult than if multicylinder engines are used. This is due to the large angular variation in the speed of the single-cylinder engine, although, of course, the use of extra-heavy flywheels will eliminate part of this trouble. As a consequence, there are more installations in which paralleling of the units is accomplished by using multicylinder engines than by single-cylinder engines.

It is well to have the alternators equipped with squirrel-cage windings on the rotor to reduce the cross-currents. Another good plan is to use exciters large enough so that one of them will be able to furnish sufficient current for both generators.

Low-Compression Type Suited to Small Plants

The low-compression engine has its field of usefulness. In industrial plants using less than a hundred horsepower, this type is quite suitable. While the history of the usual installation is one of expensive repairs and shutdowns, this is not really the fault of the engine. It has been customary for builders to claim that experienced attendance was not necessary; but many purchasers who have acted on this statement have learned how little truth there is in it. Given the care that a Diesel engine or a Corliss steam engine receives, the low-compression engine will operate satisfactorily.

While fuel oil was cheap, the saving of the Diesel engine over the low-compression engine was not great in the smaller sizes; as a result, the low first cost of the low-compression engine was the motive that caused many to be installed. With oil costing about five cents a gallon, the Diesel engine will undoubtedly be favored over the former type even in sizes less than one hundred horsepower.

Falling Chimney Wrecks Part of New England Factory

A part of the three-story frame building of the Sprague Box Co., at Lynn, Mass., was wrecked by a falling chimney recently, causing four fatalities and injuring a number of employees. The chimney failed during a gale estimated at 60 miles per hour, and had the accident occurred later in the day, the loss of life would unquestionably have been much greater. The chimney was a brick stack of rectangular horizontal cross-section, about 3 x 5 ft. inside dimensions and approximately 70 ft. high. As shown in Fig. 1, the original of which was made on the spot by a representative of *Power*, the chimney was carried upward from the boiler house of the factory along the outer wall, to which it was attached by iron straps about half-way up and also at the roof level. It extended above the roof for about 35 ft. The original chimney was built eight years ago, and twelve months ago about 8 ft. was added to its height, the stack being guyed to two parts of the factory building.

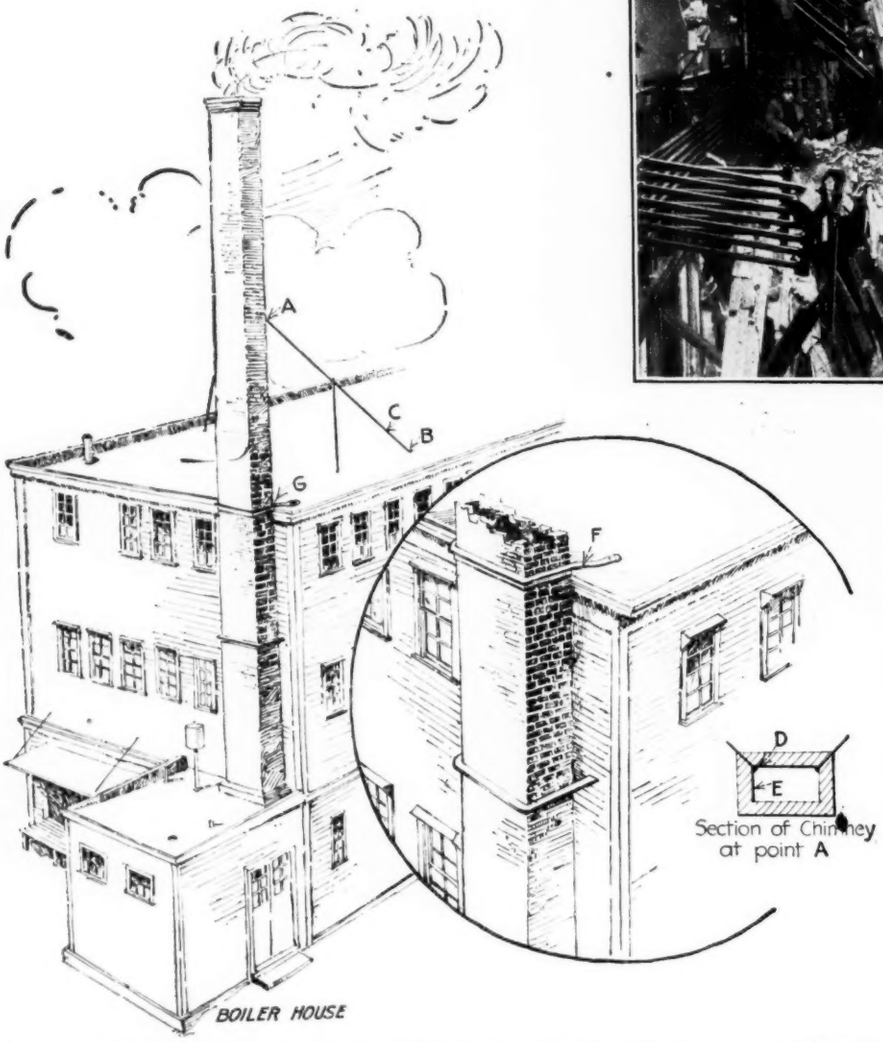


FIG. 1. DETAILS OF THE CHIMNEY, METHOD OF BRACING AND POINT OF FAILURE

In Fig. 1 *A* represents the two anchorages to the chimney and *B* the anchorages to the roof; the rods *C* are 1 in. in diameter and about 30 ft. long; *D* is an angle iron on the inside of the chimney; *E* represents the thickness of the chimney, 8 in.; *F* is an iron strap at the roof level, and *G* represents the point where the chimney broke off.

In giving way under the gale, the stack broke off at the roof level. It fell intact into the factory, demolishing three floors covering a panel or bay about 16 ft. wide and 40 ft. long, Fig. 2. The anchorages of the brace rods in the stack held. The wooden anchorages of the rods in the building structure were carried away with the rods, and the only bracing support of the stack was the stiffness of these rods. Foundation and straps were in good condition when inspected. It appears that the chimney was ill-proportioned for the height to which it was carried and that its anchorages to the roof were inadequate in size and number, guying being on one side only. All possible aid was extended to the victims of the disaster by the local branch of the Red Cross, the Lynn works of the General Electric Co., the Lynn Gas and Electric Co., J. B. Blood Co., and others, and fortunately no fire occurred.

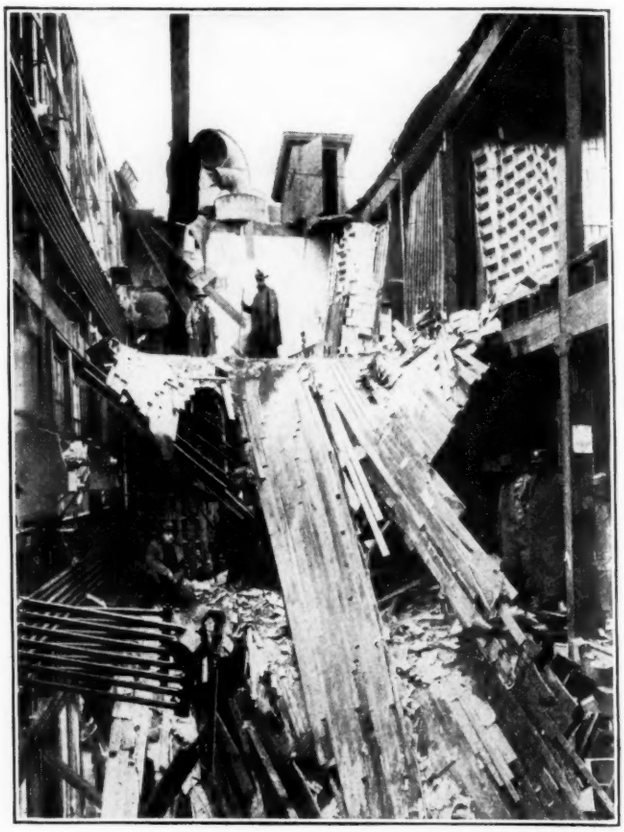


FIG. 2. THREE FLOORS WERE DEMOLISHED

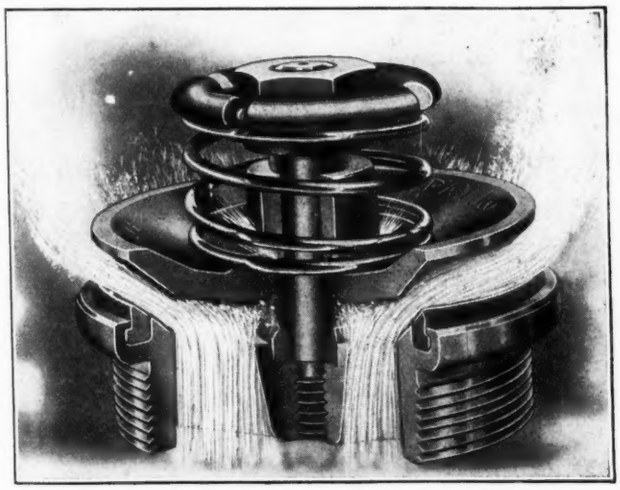
The accident occurred at 7:45 a.m., and at 5 p.m.

on the same day the débris had been removed, a new roof erected, and the chimney replaced by a 2.5-ft. steel stack 30 ft. long, erected upon the remaining portion of the brick stack. The plant resumed operation on war orders the morning after the accident. About 5 ft. of new brickwork was built upon the upper end of the old stack in adding the new section. Two courses of bricks formed the stack proper, the walls being 8 in. thick.

Scoville Pump Valve

A metal-to-metal pump valve sealed by compressible composition rings of special form is being made by the Scoville Pump Valve Co., Chicago, Ill. As shown in the illustration, the valve disk is beveled on its outer circumference and also around the hole for the stem. In grooves around the stem and in the seat of the valve the composition sealing rings are inserted. The pressure of the fluid forces the rings against the beveled edges of the valve, making the metal-to-metal joint tight, and as the rings come in contact with the valve before it is fully seated, there is little opportunity for slippage.

Wear upon the seals is small as the valve does not seat directly upon them, and renewal is comparatively simple and inexpensive. Another advantage



SCOVILLE METAL-TO-METAL PUMP VALVE

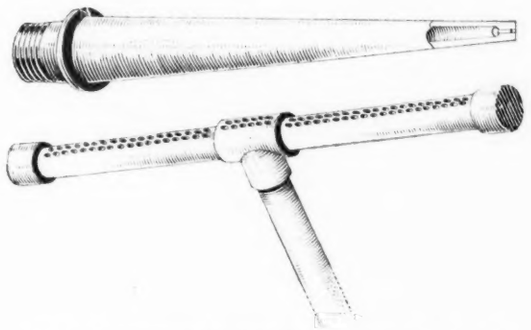
claimed for the beveled valve is a reduction in friction and loss from eddy currents over a flat disk in which the fluid flow is at right angles to the plane of the valve. Standard and pot types of valve are made.

Compressed Air for Cleaning Motors

BY D. R. SHEARER

In a great many manufacturing plants, especially those working in wood or a similar material, the driving motors have a tendency to become clogged with dust in a short time. Such accumulation of dust is a fire hazard, particularly if the motors are overloaded and liable to have coils burn out; and if a motor is not overloaded, it may heat if the air ducts are filled with dust. Moreover, the motor is not able to carry the peaks when called upon, for the reason that the additional heat cannot be dissipated. Motors should be cleaned frequently, but such cleaning with the means ordinarily at hand is a rather difficult procedure since the air ducts are usually small and difficult to clear with a brush. The windings may be brushed off externally, but such cleaning does not reach the real seat of the trouble.

One of the best methods is compressed air under considerable pressure. If the air is not available from some source already in use, it is advantageous to use a small motor-driven compressor and a storage tank. The



NOZZLES OR TOOLS FOR CLEANING WITH AIR

compressor should have a capacity of from 4 to 10 cu.ft. of air per minute at a pressure of 100 lb. per sq.in., and the tank should hold from 40 to 100 cu.ft. This size will take care of the average plant.

In piping a factory the air line can be 1-in., $\frac{3}{4}$-in. and $\frac{1}{2}$-in. pipe. Since the amount of air used in cleaning any one motor is small, a large pipe is not necessary. An outlet with a valve should be placed near each motor, or if they are grouped, several motors can be reached from one outlet with $\frac{1}{2}$- or $\frac{3}{8}$-in. hose; the smaller size is more easily handled. The nozzles can be made up of brass rod of suitable sizes and shapes, one of which is shown in the illustration. It is necessary, however, to use nozzles with small openings as a large nozzle opening would consume too much air. Probably the most useful sizes would be $\frac{3}{32}$-, $\frac{1}{16}$- and $\frac{3}{64}$-inch, and these three nozzles will meet most conditions.

Sometimes it becomes desirable to clean surfaces with air; for instance, the walls or ceilings of the buildings. This may be done with a tool made from $\frac{3}{8}$- or $\frac{1}{2}$-in. pipe in which there are a number of holes, as shown, to form a "brush" of escaping air. For ordinary purposes holes of about $\frac{1}{32}$ to $\frac{1}{64}$ in. can be used.

These small nozzles do not clog readily if all the scale and dirt is blown out of the piping. As an investment such a cleaning system will be found to pay for itself in the reduction of motor troubles and the decrease in fire hazard.

Carbon in Steel

There is more or less uncertainty in the mind of the average reader in regard to carbon in steel and how it can be got there. While there are many ways of introducing carbon into iron, one of the most direct is to throw charcoal into a ladle being filled with molten iron—simple as sprinkling salt in soup and the determination of the proper amount is the same; that is by sampling.

Centralized Mine Plant

By C. C. Muldner

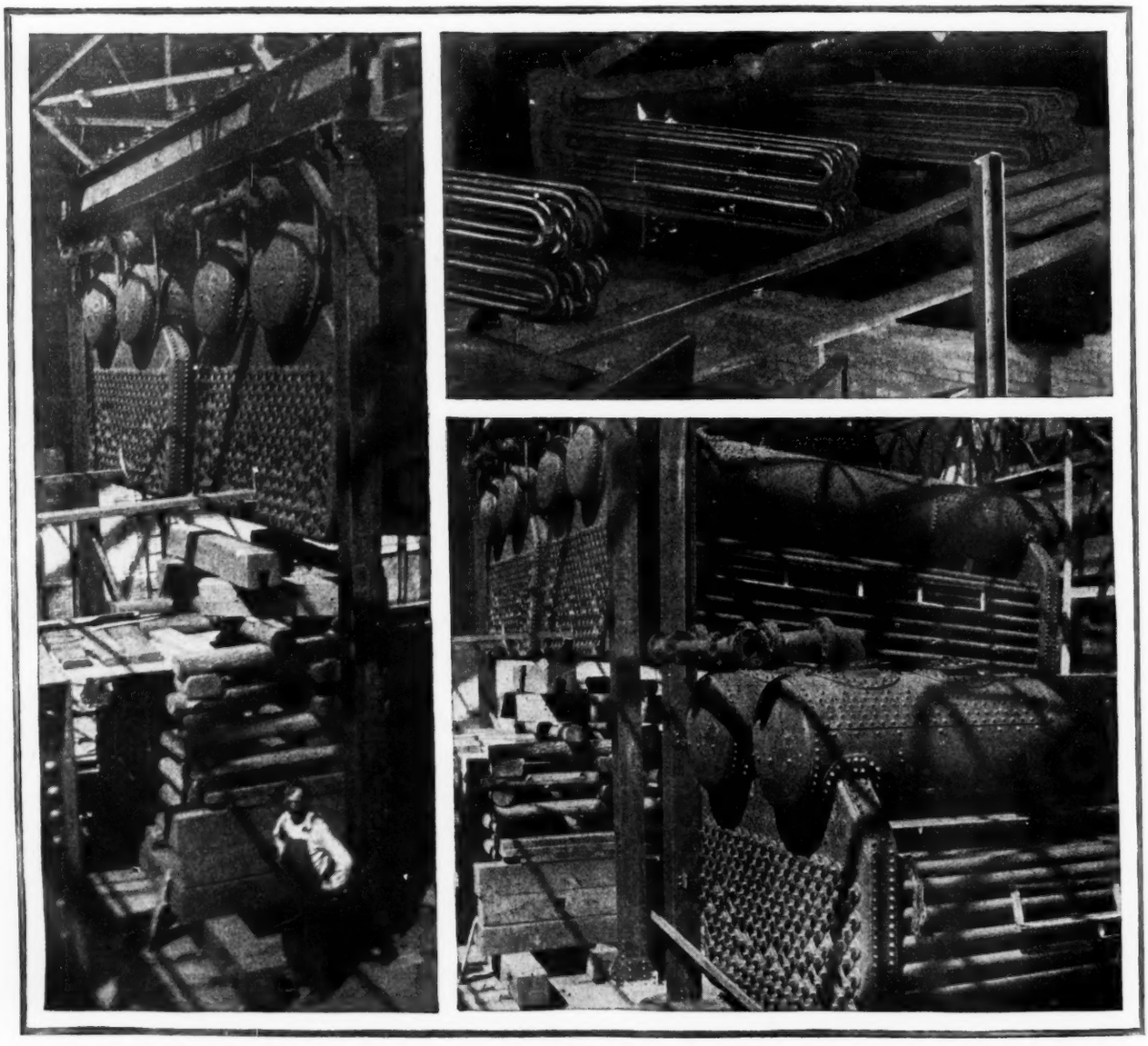
The illustrations show the boilers in course of erection in the new addition to the power plant of the Oliver Iron Mining Co., at Ironwood, Mich.

The chief feature in this setting is that two 25-ton (450-hp.) Heine boilers are hung on one gallows, there being no supporting column in the division wall between them. The overhead support consists of two 24-in. I-beams 27 ft. long, supported by two 10-in. H-beams, eliminating the usual column in the division wall, which, being completely bricked in, deteriorates rapidly, causing serious trouble. The height of the setting can be judged from the height of the man standing on the floor level and the tops of two return-tubular boilers in the background, by means of which it is expected to eliminate smoke and greatly increase the furnace efficiency and pay for the extra first cost in a short time. The temperature control connected with the superheaters maintains any desired superheat within five degrees.

This plant will be used as a central station for all the mines in the vicinity belonging to the Oliver Iron Mining Co., of which there are about thirty, to be linked together with about 14 miles of tunnels. Cables and steam pipes will transmit power, light and heat to each mine. Eventually, the mines will be electrified, thus doing away with the numerous individual boiler plants.

This is an example of the present tendency to centralize mine power plants and, in the case of coal mines, to produce electric current for distribution and sale at the pit mouth, where low-grade fuel can be profitably utilized by combining high boiler setting and superheaters in large units; and with stokers and coal- and ash-handling machinery, the cost of producing steam should be reduced to the minimum.

The transfer of electric current long distances involves a loss, of course, but it often costs much less than the hauling and handling of coal from the mine to the market. Time was when crude oil was hauled from the wells to the refineries; nowadays it is pumped for distances of several hundred miles.



TWO BOILERS SUSPENDED FROM A SINGLE GALLOWS FRAME; HIGH SETTING AND SUPERHEATERS

Editorials

Putting Their Houses in Order

THE employers have begun to set their houses in order. Some employers, not all. Careful study is beginning to replace indifferent handling of the labor problem. Necessity is forcing a modification of the autocratic policy. The worker will no longer be a chattel. He demands to be treated as a human being. His aspirations must be consulted.

There was plenty of reason in the past for the employer changing his attitude. Where he did not have strikes, he found at least indifferent and consequently wasteful labor interest. His dominant thought, though, was to hold all power. He feared that any injection of the milk of human kindness would lead the men to believe that he was weakening, that kindness was the resort of waning strength.

Yet around him there were plants that continued successful even though the men were treated like humans; aye, that increased their profits through greater efficiency and greater labor stability. Gradually the public, learning faster than the owner, forced upon him shorter hours, accident-prevention measures, proper sanitation, workmen's compensation. And lo, the industry was the gainer. There was physical response to the improved conditions; and just as surely, response in spirit, even if unconscious.

Still, the absolutism in management remained. The changes were forced, not voluntary.

Then came the war. Labor, from receiving an indifferent interest from the employer, began to get his chief attention. The supply was ostensibly short.

For a decade those who thought deeply on management problems have urged a closer study of the human element. Management inefficiency, as affecting the worker, had been berated. The value of intelligent employment and promotion systems, involving a close study of the aptitudes, ability and ambition of each employee, had been emphasized. All to no avail—until the war came.

Now the demand for skilled employment managers is far greater than the supply. With an apparent labor shortage the wisdom of putting each man in his best place, of giving him the highest type of work he is capable of doing, of encouraging him to improve himself, has been apparent.

Intelligent employment methods must become universal. They are necessary for the development of the highest efficiency of the individual as an individual and as a member of an industrial organization. Moreover, they bring employee and employer into close, sympathetic touch. Each will profit from the experience of the other.

Such contact, too, is a necessary preparation for the inevitable—coöperative management. Any scheme that is not based on confidence and sympathy will fail. If coöperative management is accepted grudgingly, if an artificial structure of labor participation in plant control is nullified by an unjust employment system, there is sure to be strife. The insincerity will prevent effective coöperative work.

And since coöperative management is to be expected as a war product, it behooves industrial leaders to prepare for the day, to put their houses in order. There must be in each plant someone whose duty is to know the worker, whose seat at the council table is that of the employee's advocate.

Such is the way that progressive employers are preparing for the industrial change that will inevitably follow the war.

Shutting Down the Isolated Plant

THERE are two sides to every question, and this applies to the methods of supplying power to manufacturing plants. Most manufacturers who operate their individual power stations do so because they find that power can be produced cheaper than it can be purchased. To be sure, the coal shortage has caused annoyance and in certain cases some losses, but it is not evident that the situation has been such as to warrant eliminating these isolated steam plants as advocated by the following extract from a recent editorial appearing in *The Central Station:*

> Never was the time more ripe for urging the shutting down, if not eliminating entirely, for business as well as for National reasons, the isolated plants which could and should be served by the central station. The stubborn owners and operators of isolated plants, and the word stubborn fits the majority of these cases, have certainly had their full measure of worry and loss during the past two months, due to the coal situation. Yet no amount of accurate operating figures submitted to them, previous to the present conditions, by central-station engineers, could move them to action.

As has been stated many times in *Power*, there are some types of isolated steam plants that should either put in new equipment or purchase power. There are others that should use purchased power part of the time, as for instance, night runs during the months when no heating is required and the load is light, but should use their own power during the yearly day run with a heavy load, and heating during the winter months. Other plants should never purchase power, but should produce their own at all times.

We agree that the isolated-plant owners are "stubborn," when it comes to discarding their power plant and substituting purchased power, but if their plants are run in an economical manner, there should be no cause for surprise as to the admission made in the editorial mentioned that "no amount of accurate operating figures submitted to them, previous to the present conditions, by central-station engineers, could move them to action."

We very much doubt that the same "accurate figures" will move them even now after the period of "worry and loss." Most isolated-plant owners have an ear to the ground when it comes to dependability and econom-

ical service, and the plight that many manufacturers have found themselves in during the last two months can hardly be an incentive for them to continue central-station service or to induce isolated-plant owners to abandon an expensive and dependable plant equipment for a service that is not as dependable and does not always serve.

Some of the recent newspaper headlines relating to this matter tell the story, but they can hardly be considered as evidence favorable to the wiping out of the isolated power plant. A Nashville, Tenn., paper has this headline: "ELECTRIC POWER CANNOT BE USED. INDUSTRY IN NASHVILLE WILL ALMOST WHOLLY CEASE TOMORROW." A New Jersey paper came out with the heading: "ALL DEPENDENTS UPON P. S. SERVICE ARE TIED UP. OFFICIALS OF THE PUBLIC SERVICE ELECTRIC COMPANY TODAY ESTIMATE THAT 2500 PLACES OF BUSINESS ARE SHUT DOWN IN HUDSON COUNTY." Another heading reads, "POWER OFF SEVERAL DAYS," and still another: "POWER OFF ALL THIS WEEK. INDUSTRIES PRACTICALLY AT A STANDSTILL. 15,000 IDLE HERE." These are only a few of the many that could be cited.

Many manufacturing plants are engaged in making war materials, and the sudden expansion of power requirements has forced them to purchase power to meet the additional demands upon their steam plants. Although big and little factories engaged in war materials have been hit by the failure of the central station to provide power, it is significant to note, according to newspaper articles, that "the —— factory operated in part, however, because it has a plant of its own. The plants of the —— Co., the —— Co. and the —— Co. are operating today because these concerns can generate their own electricity. Practically everything else in the city is at a standstill."

Central-station representatives are undoubtedly using the past and present fuel difficulties as a lever to pry isolated plants into taking their current. In fact one such gentleman stated in this office that this was the time to cover the isolated-plant field in a central-station canvass. Some will fall for it, but with the most of them no amount of "accurate operating figures" submitted to them by central-station engineers will "move them to action" that is against their own interest.

Government Coal-Price Regulation

THE regulation of coal prices by the Fuel Administration is the first attempt ever made, at least on a large scale, by the United States Government to fix and establish prices for any of the great industries. It is very important to both the public and the coal industry that the prices so fixed should be based on accurate information as to the conditions prevailing in different fields, and that, when once this information has been received, the right principles should be employed in making use of this information.

The Fuel Administration believes that it has devised a speedy and accurate method for using the cost information which it has in hand, and that it has worked out the fundamental principles which should guide it in considering applications for modifications of coal prices. It is the purpose of the Administration to announce decisions on all applications for the price revisions now before it, prior to April 1, 1918, and, prior to that time, to make such changes in the classification as seem to be necessary, in order to relieve uncertainty on this score as far as possible before the beginning of the new coal year.

By this statement, the Fuel Administration does not wish to be understood as stating that the examination of the prices now being made will complete its price work. On the contrary, it will continue to collect and study facts relating to the cost of production of coal and the prices at which it is sold. It will make such further readjustments from time to time as are necessary to keep the price on a scale fair to the public, fair to the coal industry and sufficiently high to encourage production. It hopes, also, to take measures in the very near future to encourage and insist upon the use of less wasteful methods of mining, the sale of clean coal and the more definite recognition of the different qualities of coal in the Government prices.

Rate Fixing

THE Supreme Court has decreed that a public-utilities corporation is entitled to a profit on a "fair value" of its property. Several public-service commissions consider a fair value the cost of reproduction at present prices, less depreciation.

Public-utilities corporations are actually going before public-utilities commissions and pleading for raises in rates which will enable them to pay a profit on values of their property based upon the inflated war prices of last year.

And they do this in all apparent seriousness and with the evident expectation of getting away with it. Allowable profit should be based upon the cost of the service rendered and not upon an indeterminable value of the plant required to produce it.

Frank Baackes, vice president of the American Steel and Wire Company, in criticizing the Fuel Administration, says: "You cannot expect a tailor to operate a blacksmith shop successfully, nor can we expect too much of an administrator who was nothing more than a professor of economics."

Probably a representative of the coal producers could have induced his associates to produce more and cleaner coal at a less price; and could have made a crippled railway system distribute it to better advantage. Eh?

The Toronto *Call* announces that Patrick K. Gallagher, of Nelson, B. C., has developed an internal-combustion engine in which oxygen will take the place of gas or oil. It won't do, Patrick. Oxygen is working now in every kind of combustion engine, internal and otherwise, even in the mysterious motor processes of the animal organism; but it needs fuel or food to work with. If you want to make a real fuss with your idea, keep people guessing about it, like Garabed.

The essentials—Students of Divinity and Dentistry are exempt from the draft; students of engineering are not.

Correspondence

Grate Area and the Underfeed Stoker

With hand-fired grates or overfeed stokers operating on natural or induced draft, the question of grate area is an important one. With natural draft the furnace suction that can be obtained is limited by the height of the stack it is feasible to build. In the case of induced draft, infiltration losses through the boiler setting and grates, which become prohibitive at high negative pressures, limit the possible furnace suction. The amount of coal that can be burned per square foot of grate is limited by the available furnace suction, and consequently, if it is desired to double the capacity of a boiler, it is necessary to double the amount of grate surface.

In the case of the underfeed stoker, grate area is not of so much importance. The capacity that can be obtained from the stoker is dependent only to a small degree upon the grate area. The amount of coal that can be fed by the stoker is limited only by the mechanical strength of the stoker parts. To burn this coal, it is only necessary to provide a sufficient blast pressure under the grates, sufficient openings through the grates and means for keeping the fuel bed broken so that the air may find a passage up through it. The draft suction in the furnace of an underfeed stoker should be kept as nearly equal to the atmosphere as possible at all ratings to prevent infiltration and also to stop gases escaping from the furnace into the boiler room. The resistance of the fuel bed is taken care of by the forced-draft pressure under the grates. To a certain extent, the resistance of the fuel bed is inversely proportional to the percentage of volatile in the fuel. The higher the volatile the less draft pressure under the grates necessary for burning a given amount of fuel. Infiltration losses actually decrease at high ratings. The reason for this is that the limit to capacity with an underfeed stoker is usually set by the ability of the chimney or induced-draft fans to get the gases away from the furnace without permitting a pressure in the furnace. The capacity limit is usually not due to inability to burn sufficient coal.

With the underfeed stoker combustion efficiency does not depend to any great extent on the grate surface, but is dependent more upon distillation or retort volume and total volume of coal in the furnace. To show this the underfeed stoker may be compared to a continuous gas producer. It is well known that the highest efficiency of combustion would be obtained from a gas producer with a fire bed several feet thick. The underfeed stoker and the gas producer are similar in the following functions: (a) Distillation of gas by approach to hot zone; (b) mixture of gas and air in the fire, using the tortuous passage between lumps as a means of thoroughly mixing volatile matter and air; (c) heating of the mixture to a high temperature as it passes through the topmost layer of the fire.

The great difference between the underfeed stoker and the producer is that the producer is not intended to complete combustion but only to produce a combustible gas, whereas the stoker must not only produce the gas but burn it and the resulting coke. The temperature of the fire of the underfeed stoker is much higher than the producer, and this sets a limitation to pursuing the analogy too far. The high temperature with the underfeed stoker causes the formation of masses of clinker, and if a great depth of fuel bed were used with the stoker, it would be impossible to keep it broken up and free from clinker by any practical method of stoking or mechanical poking. Within the limits of the clinker problem, that stoker having the greatest distilling volume will have the highest combustion efficiency. The higher the percentage of volatile in the coal, the greater the necessity for large retort volumes in order to get high capacity and efficiency.

The difficult feature of coal combustion is not the burning of fixed carbon, but of volatile matter. The burning of volatile matter is a function of the relative thoroughness of mixing air and gas and of temperature. The temperature must be kept above the ignition point or the flames will be extinguished. The thoroughness of mixing introduces the element of time. If mixing is done in the fuel bed, the thoroughness will depend upon the length of the mixing passages; that is, the depth of the bed. If mixing were perfect in the fire bed, which might occur with a deep producer fire, there would be little or no flame, and surface combustion would practically result with a bed of hot coke as refractory material. If the depth of bed is insufficient for perfect mixing, flame occurs and furnace volume is then required to provide the length of path to complete the mixing. For the highest efficiency, combustion must be completed and flames disappear before contact with any heat-absorbing surface, otherwise extinction of the partly burned material occurs, usually with soot deposit, and part of the gases must escape unburned, unless secondary combustion can be established, as for instance, at the top of the first boiler pass.

In general the problem of combustion is that of carburetion, and the stoker might well be compared to a carburetor. The dictionary defines a carburetor as an "apparatus used to charge air or gas with volatilized hydrocarbons." The verb to carburize means "to combine or impregnate with carbon." A stoker fire, or the fire in any furnace, is a device for carburetting the air passing through the fuel bed. The hydrocarbons and carbon are volatilized by the heat, and then they impregnate the air so that it becomes a combustible gas. Combustion efficiency depends on the accuracy of the mixture. The capacity varies with the volume of air passed through the fuel bed and impregnated. Grate area is of some importance, but depth of fuel bed is the essential feature, for depth is what promotes better mixture of gas and air. Any carburetor device is efficient

as it secures mixture in right proportions. Thus the tortuous passages through a deep fuel bed of small area are more effective than the relatively direct passages through a thin fuel bed of large area.

As an index of the value of an underfeed stoker, the relation between distillation or retort volume and total volume of coal is most important. By distillation or retort volume is meant the volume of coal in the retorts below the tips of the tuyeres or grates, including the throat under the front wall in front of the feeding plunger. By total volume of coal is meant the retort volume plus a one-foot thickness of fuel over the entire surface of the stoker. This one foot will allow for the usual thickness of 18 to 24 in. in the thickest part of the fire down to 6 or 8 in. on the overfeed section and the dump grates. This same comparison might be made by obtaining the ratio between retort volume and grate surface. Distillation and mixing of the volatile matter occurs clear to the surface of the fire so that the relation between total volume of coal and the square feet of grate is also important. Combustion of fixed carbon of course predominates near the surface of the fire, while in the retorts proper distillation and mixing is the sole function.

The most important function of the underfeed stoker consists in the burning of volatile matter. For this reason the best comparison of an underfeed stoker consists in getting either the ratio between retort volume and total volume or between retort volume and grate surface. The usual practice in figuring square feet of grate surface is to use the projected area of the stoker including dump. Combustion actually takes place with the underfeed stoker from the front wall clear back to the bridge-wall. The path of least resistance for the air through the fuel bed is generally toward the bridge-wall. Consequently, even if there is no definite air supply at the rear end of the stoker, there is still ample air coming through from the fuel bed above to maintain active combustion. For this reason it is perfectly legitimate to include dump-grate area when figuring the grate surface of an underfeed stoker.

F. H. DANIELS,
Worcester, Mass. Sanford Riley Stoker Co.

Turbine Accidents

The list of turbine accidents by C. H. Camp, in the Nov. 20 issue of *Power*, covering a period of seven years, justifies the present writer's claims for overspeed tests notwithstanding the small number of accidents due purely to explosions of the turbines. When one considers that in a period covering seven years the casualty companies, as the author states, can record only 19 accidents due to explosions, it is apparent that "turbines which have exploded due to overspeed or overpressure in the low-pressure stages have been very few."

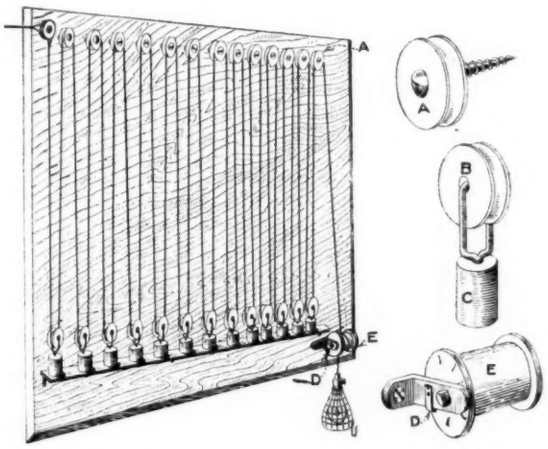
In most cases the explosions or accidents were due not to inherent faultiness of the turbines themselves, but to causes separate from the turbines and mostly due to carelessness on the part of the operators or to improper electrical protection. It is not proposed nor intended to be understood that a 100 per cent. overspeed test on the turbine will make it safe against explosions. It will not be required if the trips and governors work properly; but if the governors should refuse to act, the additional factor of safety of a machine tested to a 100 per cent. overspeed would give the attendant, or watch engineer, an opportunity to trip the throttle by hand before the turbine rotor reached the breaking point.

From careful examination of the list of accidents submitted I am of the opinion that most of them were due to faulty and careless operation or attendance, as in well-conducted plants the engineer in charge makes it his business to ascertain that the governor does not stick and that the relief valve will relieve the pressure if need be. Relief valves, however, should always be fitted with safety measures, such as auxiliary tripping devices actuated by the governor of the turbines.

New York City. W. F. SCHAPHORST.

Adjustable Extension Lamp

Anyone who has worked in a shop, power plant or any place where a portable electric lamp is used, will quickly become impressed with the annoyance that the loose extension cord causes when thrown promiscuously



PARTS AND ASSEMBLY OF ADJUSTABLE EXTENSION LAMP

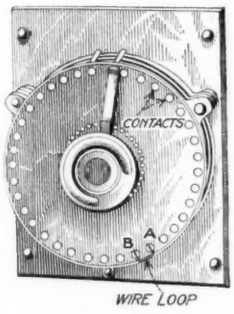
about the floor. An efficient method of avoiding much of this annoyance is shown in the accompanying illustration. The extension cord passes alternately over a series of fixed and movable pulleys as shown. The fixed pulleys *A* are ordinary porcelain insulators mounted on round-head screws, at the upper end of a panel which should be made of slate or asbestos board. The panel can be attached to the wall in any convenient place. Small cast-lead weights *C* are attached to the movable pulleys *B* to keep the cord taut. The movable pulleys are also made of porcelain insulators, and the connection between the pulley and weight is made from a piece of wire bent to the proper shape.

The lamp cord makes one and a half turns around roller *E* at the bottom of the board and passes out to the lamp. A small spring catch *D* allows the cord to be easily pulled out to the desired length, but prevents it from slipping back. It is obvious that upon pulling out the extension cord the movable pulleys will be lifted, shortening the distance between them and the fixed pulleys. By releasing the catch *D* the cord is allowed to return slowly to its normal position, as shown in the diagram.

M. P. BERTRANDE.
Ozone Park, N. Y.

Repairing an Open-Circuit in a Field Rheostat

Repairing open-circuits in field rheostats having the resistance encased in porcelain or other insulating compounds can be accomplished as follows: Assuming that the open-circuit has been located between contacts *A* and *B* in the figure. A radial slot is cut with a hacksaw in the center of each of the two contacts between which the open-circuit is located. Cut these slots about $\frac{1}{16}$ in. deep. Then make a loop of No. 20 B. & S. gage copper wire, as in the figure, and drive it down in the slots. The edges of the slots are slightly upset by a small cape chisel to hold the wire firmly in place, and then soldered to the contacts. All excess of solder is removed so as not to interfere with the contact-arm travel.



FIELD RHEOSTAT

Brooklyn, N. Y. SAMUEL SPAGNOLA.

Starting Diesel Engines Under Difficulties

As all Diesel-engine operators know, it is difficult to start these engines when they are cold—that is, below a temperature of 40 deg.—and especially so when they have been exposed to freezing weather for a day or two. The builders usually recommend that they be installed where they can be kept from getting so cold. About the first of November, 1917, I took charge of a plant having two Diesels, in which the engines are under the shelter of a corrugated-iron structure that has been through the vicissitudes of fire and reconstruction and is more of a refrigerating room in winter than anything else.

In addition to the foregoing, the starting-air tanks are a long distance from the engines, and there are ten elbows and bends in the starting-air line. This line is also too small for efficient starting, being of 1-in. double-extra-heavy pipe. The engine is belted to a lineshaft carrying several pulleys and belts, driving the air compressor and circulating pumps and two generators, as well as several other belts that usually are running on loose pulleys, but altogether producing a considerable friction load. And then the engines are old and badly worn in the cylinders so that compression is poor. In fact they were in such shape that the employees of this plant who had been handling them had not been able to start them since last June.

After overhauling and repairing these units as best I could, so that we could get some service out of them before the final shutdown for rebuilding, I started up one without much trouble and continued to do so every day for a week; then the temperature dropped to 19 or 20 deg. above zero and stayed there for several days. On Monday morning I attempted to start up and before quitting had lost all the air that we had stored without getting the engines running. It was then necessary to connect up the steam engine of an ammonia compressor that was belted to the lineshaft and take the belt off the Diesel's pulley so as to drive the air compressor, and pump up the starting tanks again before we got started.

When it was convenient to shut down for a day or two, I cut into the steam line running through the building and connected it into the circulating-water system as near to the cylinder jackets as possible. Now, when it is too cold to start easily, I turn live steam through the water jackets and in ten to fifteen minutes the cylinders are warm enough to start on the first attempt.

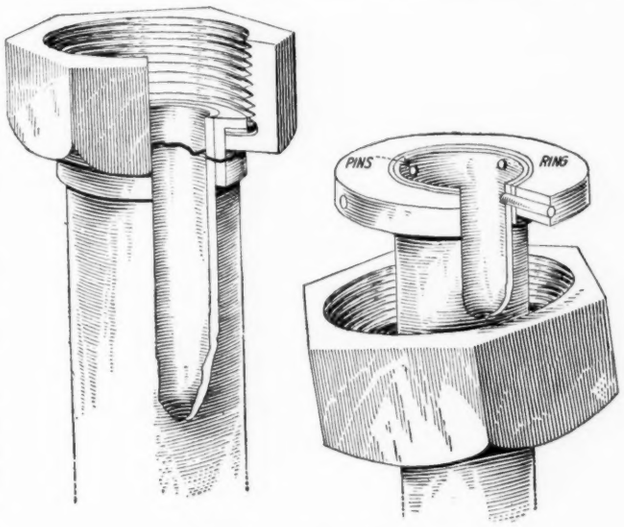
Of course not all Diesel plants are so arranged that they can have steam, and many are so housed that they do not need any external means of warming up, but doubtless there are a good many who might be able to use this method and so get around a serious difficulty.

Austin, Texas. F. C. WILLIAMS.

Repair to Copper Circulating Pipe

The copper pipe connecting the jacket of an oil engine with the radiator broke near a union, as shown by the irregular line in the illustration. It was repaired by the engineer in a short time as follows:

The coupling was separated and a ring was shrunk on the end of the broken pipe and pinned, after



BROKEN UNION REPAIRED

which the pipe end was peened, smoothed off and the union put together as before. The pipe when joined was about an inch shorter than originally, but fortunately the radiator could be moved that amount without difficulty. This job seems all the more creditable when it is considered that only a few hand tools were available.

West New York, N. J. LUDWIG V. LAUTHER.

Distinguishing Iron from Steel Pipe

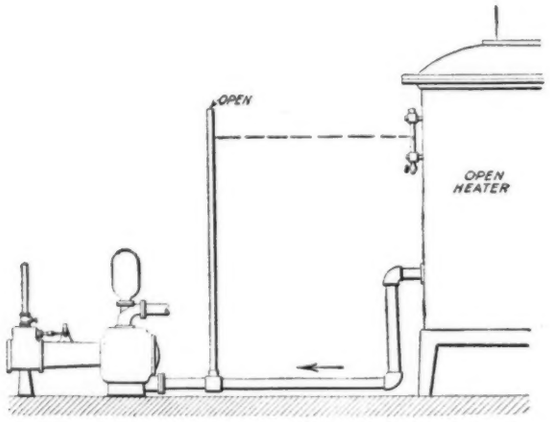
I have noticed several articles in *Power* relating to methods of distinguishing iron pipe from steel, and I herewith present my method, which is very simple.

Aqua fortis (weak nitric acid) applied to the surface of steel produces a black spot; on iron the metal remains clean. By this method the slightest vein of iron or steel can be readily detected. J. W. STANLEY.

Braemar, Tenn.

Vapor Relief on Pump Suction

A feed pump which got water from an open heater situated about four feet above the pump gave trouble by pounding—not only at the pump, but in the discharge line. Various remedies were tried with no success until



OPEN END PIPE CONNECTED TO PUMP SUCTION

an air pipe was connected to the suction line with the open end extending above the water level of the heater, as shown in the illustration, after which the trouble ended. N. C. GLEASON.

Northport, Wash.

Piston Packing Burns Out—No More

My S.O.S. regarding piston packing burning out in the issue of Jan. 22, page 129, brought several fine answers by mail from widely separated places—Staunton, Ill.; Denver, Colo.; Port Huron, Mich.; Trenton, N. J.; and Milford, Mass. I have, of course, replied to these letters, thanking the writers for their interest. Is there any other group of mechanics except engineers who would use their time, stationery and stamps simply to help out a brother engineer who is a perfect stranger to them? One thing that is noticeable about engineers is their unselfish willingness to help others.

Some of the suggestions given me are peculiar, and probably I never would have thought of them. Following, in part, the advice given by two of my correspondents, one suggesting metallic packing and another a certain brand of steam packing, I compromised and used both. Instead of a concave ring in the back of the packing box, I now use a flat one and have made the end of the follower, or gland, flat and use alternate rings of a good high-pressure asbestos rubber packing and rings of plastic metallic packing. Some, no doubt, will raise their hands in horror at such an idea, but the proof of the thing is in the satisfactory results gained.

Another peculiar thing I noticed in the replies received is that the electric men are so certain the fault can be traced to defects in the electric end of the work, while the steam men are just as certain that the trouble is in the steam machinery. However, the steam men were right in this case, so far as I can see in the short time since I made the change. I have tried it severely by drawing the packing tight and also by leaving it loose, but it does not get hot. JAMES E. NOBLE.

Portsmouth, Ont., Canada.

Starting Synchronous Motors

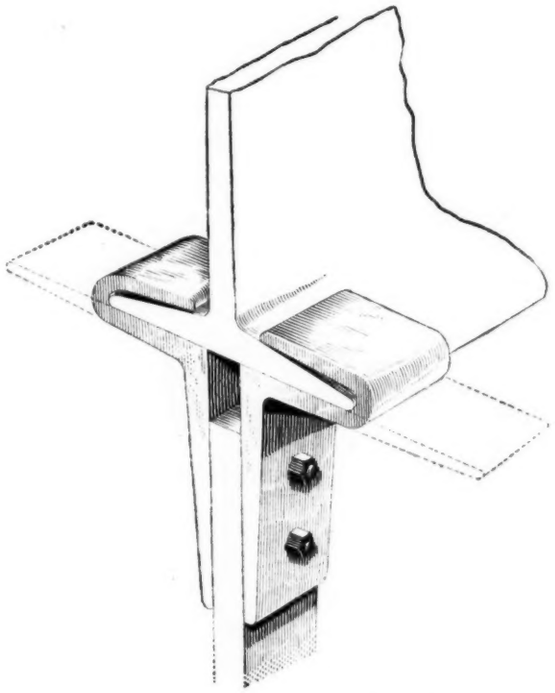
In starting up the synchronous motor in our plant, there is usually one man at the switchboard and another, generally the fireman, at the compensator for starting the motor. At starting, the man at the switchboard closes the oil switch and the attendant at the starting compensator throws the lever to the starting position. When the motor comes up to speed, the man at the switchboard closes the field switch and the attendant at the compensator throws the lever to the running position.

There are times when it is not convenient for the fireman to leave the boiler room in order to help out. It is a case of either waiting or getting someone else. This, again, is often out of the question. To start the motor without an assistant, I first tie the lever on the starting compensator to the starting position, then I go to the switchboard and close the oil switch; when the motor gets up to speed, the field switch is closed; after this I go to the compensator, release the starting lever and throw it to the running position; then I return to the switchboard and make the necessary adjustments. In this way I am able to satisfactorily put the motor into service without the help of an assistant.

Middletown, N. Y. THOMAS M. GRAY.

Hanger-Clamp for I-Beam

The best and strongest kind of an I-beam hanger clamp I know of, can be made from two pieces of 3-in. angle iron sawed off about two inches wide, heated and



HANGER-CLAMP MADE OF ANGLE IRON

one end or flange bent back and the other drilled for the strap, as shown. The thickness of the angle is where it is most needed. W. H. H. PLOWMAN.

Philadelphia, Penn.

Inquiries of General Interest

Flow of Steam Through 6-In. Pipe—What weight of steam at 150 lb. gage would be delivered per hour by a 6-in. steam pipe 100 ft. long? B. C. W.

The rate of flow would depend on the drop of pressure; that is, the number of pounds per square inch the steam pressure would be reduced in traversing the full length of the pipe. A simple form of diagram for computing the flow of steam in pipes, based on the Babcock formula, with examples, is given on pages 836-7, June 13, 1916, issue of *Power*. For a continuous flow and pressure drop of 5 lb. per sq.in. the discharge would amount to about 9000 lb. of steam per hour.

Diameters of Fire Tubes of Boilers—What is the rule for the diameter of fire tubes of return-tubular and vertical fire-tube boilers? C. H. S.

For natural draft the usual rule is to allow one inch of nominal or outside tube diameter for each 4 ft. of tube length for use with bituminous coal, and for use with anthracite, 1 in. of nominal diameter for each 5 ft. of tube length. For artificial draft the size of tubes may be considerably smaller, according to the force of draft and tendency of the fuel to clog the tubes with soot. For vertical fire-tube boilers, where the course of the heated gases is short and direct, the ratio of tube diameter to length is usually about 1 to 70.

Reason for Lap on Corliss Steam Valves—Why is lap given to the steam valves of single-eccentric Corliss engines? W. R. S.

For obtaining compression of the exhaust the exhaust port must be closed before the piston reaches the end of the stroke. It is not permissible to obtain earlier closing of the exhaust valves by lengthening the exhaust-valve rods, as that would make the valves later in opening and the steam would not be released until after the piston had completed its stroke. Therefore to obtain earlier compression and release, the eccentric is advanced; that is, set ahead of the 90-deg. position. All valve events are thus made earlier, and to delay uncovering of the steam ports by their valves until the beginning of the stroke, it becomes necessary to add lap to the steam valves

Cushioning of Duplex Pump—How can a duplex pump be given more cushion? H. D. W.

In the ordinary duplex pump, the ports and passages for admission of steam are at the ends of the cylinder, and those for discharge of the exhaust are nearer the middle of the cylinder. The piston in approaching the head covers the exhaust port, while the exhaust edge of the valve is still open and the steam end of the valve covers its port. The volume of steam thus entrapped in the end of the cylinder and steam passage is constant, and there is no convenient means of covering the exhaust port earlier so as to obtain more cushion, excepting to provide a wider piston ring. On pumps of over 10-in. stroke, for regulating the cushion an opening is provided through the partition between the steam and the exhaust passages with a valve inserted for relieving the piston of too much cushion, but cushioning cannot be adjusted to more than the amount obtainable with this valve closed.

Noise in Ends of Cylinder—What causes a noise in a steam-engine cylinder at each reversal of the stroke of the piston? W. E. B.

With a noncondensing Corliss engine, a rattling noise may be due to the exhaust valves being raised from their seats when the steam expands to such a low pressure that the valves are raised from their seats by pressure of the atmosphere. If the noise from this cause continues when the engine is running at regular speed, it can be stopped by throttling or reducing the initial steam pressure, or by joining together the indicator connections of opposite ends of the cylinder with a very small opening. A slapping noise may result from loose-fitting piston rings driven against the sides of the grooves by sudden change in difference of cylinder pressures on opposite sides of the piston, or from frictional resistance to being dragged at each reversal of the stroke. A rattling noise may be due to a broken piston ring or some material out of place, and when it occurs the engine should be stopped as soon as possible and inspected to discover loose or broken parts that might score the cylinder.

Ventilation of Paper-Machine Room—How can a paper-machine room be ventilated to prevent deposit and dripping of condensation from the roof or ceiling? W. H. D.

To retard the condensation it is necessary to keep the roof or ceiling warm. This is best accomplished by sheathing under the roof or ceiling to form a dead-air space and liberally warming the sheathing with steam pipes hung close to its under side and evenly distributed. The space over the machine where vapor rises should be covered with a hood kept clear of vapor by an exhaust fan discharged outside of the room, and for general ventilation of the room to remove moisture, there should be exhaust fans or suction ducts in the side walls, placed at intervals near the roof or ceiling.

Equivalent Evaporation from and at 212 Deg. F.—With an evaporation per pound of coal of 8¼ lb. of feed water at 208 deg. F. into steam at 140 lb. boiler pressure and 96 per cent. dry, what is the equivalent evaporation from and at 212 deg. F.? J. W. N.

Each pound of the feed water contained 208 — 32 = 176 B.t.u. above 32 deg. F. According to Marks and Davis' Steam Tables, a pound of steam at 140 lb. per sq.in. gage, or 155 lb. absolute, contains 332.9 B.t.u. in the water and 861 B.t.u. latent heat; hence with the steam 96 per cent. dry each pound contained 332.9 + (861 × 0.96) = 1159.46 B.t.u. and each pound of the feed water must have received 1159.46 — 176 = 983.46 B.t.u. The evaporation of a pound of feed water from and at 212 deg. F. requires the latent heat of evaporation, or 970.4 B.t.u.; hence the factor of evaporation was 983.46 ÷ 970.4 = 1.0134, and the evaporation was equivalent to 8¼ × 1.0134 = 8.36 lb. of water from and at 212 deg. F. per pound of coal.

Thickness and Weight of Lead Pipe—What is the rule for finding the proper thickness and weight of lead pipe? P. F.

The thickness of lead pipe required to withstand a given pressure may be calculated by the formula,

$$T = \frac{0.433 \times H \times R}{2745}$$

in which

T = Thickness of pipe in fractions of an inch;
H = Head of pressure in feet; (water)
R = Radius of pipe in inches;

from which

$$T = 0.0001578 \times H \times R.$$

For lead a factor of safety of 10 is required, hence for practical application $T = 0.001578 \times H \times R$, or if we take D = the diameter of pipe in inches, instead of the radius, $T = 0.000789 \times H \times D$.

The formula for the weight of lead pipe is:

$$W = 3.86\ (D^2 - d^2);\ or\ 3.86\ (D + d) \times (D - d)$$

in which

W = Weight of pipe per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
3.86 = A constant.

The Coal Problem*

BY E. G. BAILEY

THE biggest and most important question before the American people today is the coal problem. Some may disagree and claim that it is transportation. But sift the present situation to the bottom, and you will find that the coal problem, or rather the abnormally high percentage of ash and impurities in the coal, is like sand in the bearings of transportation, of ocean shipping and of practically all industries, causing them to slow down at the most critical time in our history.

Coal is bought solely for the combustible elements it contains. The less ash and impurities in the coal the less number of tons you need. The greater the demand for coal the higher the price and, under present conditions, the poorer its quality. The price has been regulated, but the quality has run riot.

Why have we allowed this to happen just at the time when we need *heat units* in their most concentrated form? Why are the railroads burdened today with hauling millions of tons of utterly worthless dirt? To say that this excess of impurities in the coal coming on the market today is worthless does not describe the situation. The price paid for this dirt is only a small fraction of the damage. The rest of its cost is in the decreased efficiency, the lowered capacity, the increased labor and the excessive repair bills involved in the combustion of this coal—and in the necessity of closing down industries because of the lack of coal which might have been shipped in place of these so-called "worthless," but really exceedingly costly, impurities.

Impurities in Coal

Through the past winter we have heard a great deal of talk about the deterioration in the quality of coal, the increase of ash, slate, sulphur and other impurities. We know this has occurred, but let us see how much it has amounted to, how much it has cost, and we can decide better what efforts should be put forth to remedy this difficulty.

We find from reliable sources that the coal received in many of the largest power plants in the country has increased by 5 per cent. to 10 per cent. in ash and has decreased in heating value by 8 per cent. to 12 per cent. Many good authorities state that the amount of coal consumed in their plants has increased 10 per cent., entirely owing to the inferior quality of coal received today as compared with that received previous to 1916. Figures from a prominent manufacturer who has received coal from the same district during the past seven years and has followed its quality closely by analysis and other means show a decrease of 9 per cent. in B.t.u. during the calendar year 1917 as compared with the average of five years, 1911 to 1915 inclusive.

War conditions should be borne in mind in this connection. We should not assume that the quality of all coal mined has decreased in this same ratio, for the Navy and other Government requirements have increased by several million tons, and they rightfully are getting the better coal. Hence, some of the decrease in the quality of coal going to industrial plants and locomotives has been due to confining their supply to the mines of inferior quality. But evidence is at hand to show that coal coming from the same mines carries a much higher percentage of bone, slate and free impurities than it formerly did, and as a conservative estimate I am confident that the increased coal consumption of this country during the year 1917 due to the inferior quality resulting from neglect of preparation at the mines, tipples and breakers amounted to at least 5 per cent. In other words, of the approximately 600,000,000 tons of coal produced and shipped to market during the last year 30,000,000 tons was worthless dirt, slate and rock.

How much has this increase in impurities in coal cost the United States during the last year? In the first place coal has been worth on an average, counting contracts and all, about $2.50 at the mines. The average freight, including both rail and vessel, paid on all coal produced is probably in the neighborhood of $1.50 per ton. So that the 30,000,000 tons of dirt which has been delivered to the consumer has cost about $120,000,000 during the past year.

But this only takes into consideration the cost of the coal delivered to his plant. He then has the additional cost of firing this inferior coal, repairing furnaces, stokers, locomotives and the cost of handling the ashes. These items would add a few million dollars more, but that is a mere bagatelle compared with the cost due to the shortage of coal, the closing of plants and our heatless holidays. Estimates by various authorities on the cost of the heatless holidays range from one billion dollars on up, and that was probably, for the time being, the best and cheapest way out of the difficulty.

Coal Shortage or Dirt

We have been talking about the coal shortage, while in reality we have been loading our cars and locomotives with slate and impurities instead of coal, and had coal of the former quality been shipped to market, we would have had 30,000,000 tons more real coal than we did get.

The effect of this increase in the percentage of ash has been cumulative. Storage piles have been gradually exhausted, and the supply to consumers has diminished to absolutely nothing in many cases, due to each day's coal consumption requiring 5 per cent. more than it otherwise would, because of the high percentage of ash alone, regardless of weather conditions or increased load. Suppose that all of the slate and impurities corresponding to this 5 per cent. increase had been concentrated into two or three weeks of normal shipments during the middle of the winter and this 30,000,000 tons of pure slate and rock were loaded into 1,000,000 railroad cars without any coal mixed with it. Every American citizen would have been up in arms in a minute, and indignation societies and vigilance committees would have emptied the slate out along the railroad tracks and started the empty cars back to the mines to be loaded with coal instead of impurities. But the final result has been the same.

We should also remember that the inferior quality of coal, in addition to tying up 1,000,000 railroad cars and requiring the use of thousands of locomotives, has also seriously affected the operation of the locomotive itself. The locomotive is a complete power plant, with grate area, size of nozzle, draft, steam consumption, etc., very nicely balanced. If either the quality or character of coal is changed on a locomotive, its efficiency and capacity are affected. Today locomotives are receiving, not only the poorer quality of fuel, but coal of widely varying character due to the allotment of railroad fuel to all mines. This has resulted in greatly reducing the hauling capacity of the locomotives.

In buying coal we have been so accustomed to expect the quality to decrease when the price went up that we considered it inevitable. We thought there was no remedy. The coal operator has not been wholly to blame, because he could not control the preparation of coal at the mines of his competitors. If he was conscientious and prepared his coal, he was the loser and the man who shipped dirty coal to the market obtained his profits.

The cause for this condition is well known to anyone at all familiar with the mining of coal; the reason is that the technically trained men of this country have failed to master a difficult problem they tackled several years ago and would have mastered by this time, had they had the courage of their convictions and the ability to handle human-nature problems as well as engineering.

In mining coal we find the ash occurs in two general forms, intrinsic ash and extraneous or free impurities. The intrinsic ash is locked up in the coal, so to speak, and is inseparable from it. The purest lump of coal contains a percentage of ash that is thoroughly mixed through it, much like the ash in wood. From any one coal seam in a district this intrinsic ash usually runs fairly uniform, although it may vary widely in different coal seams, in different districts, or even in different strata of the same seam.

*Lecture (somewhat condensed) delivered at the Johns Hopkins University, Baltimore, Md., Feb. 27, 1918, as one of the J. E. Aldred Lectures on Engineering Practice.

The extraneous or free impurities usually consist of slate, shale or sand rock from the roof of the mine, and clay from the floor, and sometimes slate, shale and sulphur balls are sandwiched between the coal strata. The slate and shale strata in the coal seam itself are the most difficult to eliminate because they are more or less broken and intermingled with the coal when it is shot down and require extra labor and special care on the part of the miner to throw back these impurities or load them separately into mine cars for the dump. Small sulphur balls are still harder to detect because they are usually covered with coal. Large ones should be detected by their weight. The amount of free impurities likely to come from the roof varies widely with its character. Some mines have a very firm roof that seldom breaks, while in others it crumbles and falls badly, mixing in with the freshly mined coal much like the strata of slate running through the seam. There is little excuse for loading dirt from the floor of any mine. Sometimes the fireclay bottom is very soft, making it difficult to prevent its being shoveled up with the coal, and again the mining-machine operators may carelessly permit some of the bottom to become mixed with the slack or fine coal.

There is another form of impurity generally known as "bone." This is really a stratum of coal containing an abnormally high percentage of intrinsic ash. The ash in bone coal usually runs about 30 per cent., although it may be much higher or even lower. As there is no distinct division between coal and bone, there is often a difference of opinion as to what should be loaded as marketable coal.

How Coal Is Usually Cleaned

In normal times there is a great deal of real competition between different mine operators, in selling soft coal at least. In meeting this competition the operator is forced either to sell at a lower price or produce a superior quality of coal. He, therefore, puts forth considerable effort and goes to extra expense to produce as low-ash coal as possible. This preparation of the coal is accomplished by compelling the miner to throw out all free slate, bone and other impurities previously mentioned. Inspectors examine the conditions of the mine—which, by the way, may vary a great deal in different parts of the mine as it develops—and they instruct the miner just what to load out as coal and what to throw back in the gob as refuse or load out separately for the slate dump. Additional cleaning of the coal is done on the railroad cars as each mine car is dumped, and during the last ten years many mines have been equipped with picking tables. In many districts the slack and smaller sizes of coal have the extraneous or free impurities removed by washing. At anthracite mines the slate and bone are picked out of the larger sizes in the breakers and removed from the smaller sizes by washing.

In all cases the preparation and cleaning of coal increases the cost to the operator, both for labor and equipment as well as the actual tonnage of impurities and some accompanying coal that is removed. The customer has been glad to pay more for the cleaner coal because it saved his paying the freight on slate and impurities.

In times of normal condition in the coal trade, which existed between the years of 1903 and 1916, competition carried the preparation of coal so far that a great deal of really marketable coal was thrown aside or left in the roof or floor of the mine, merely because it contained a slightly higher intrinsic ash than the remainder of the seam. Oftentimes this amounted to as much as 10 to 20 per cent. of the total coal in the seam, while its elimination reduced the ash content in the coal as shipped by only 1 or 2 per cent. This is one of the extravagant wastes which has taken place, and which has been so frequently referred to by the Bureau of Mines in support of its estimate that 50 per cent. of our coal resources was wasted beyond recovery in the mining. Another big waste of our coal supply has been due to mutilation of the thinner seams or those having a higher ash content, by first mining the thicker and better seams underneath.

There was an increased demand for coal in 1916. Naturally, prices began to soar, and many consumers foresaw what was coming and were glad to pay any price in order to get coal and fill up their storage space. This condition continued through the winter of 1916-17 until it was of common occurrence to pay as high as $5 and $6 per ton for bituminous coal at the mines. Most of the purchasers were so anxious to get coal that they forgot all about quality and were willing to take anything at any price, in order to keep their plants in operation.

It is only logical, under such conditions, for the mine operator to ease up on the preparation of coal at the mines. He has ample market at a high price for every ton of coal that he can load.

Some may think that the price of coal at the mines as fixed by the Government in August, 1917, being lower than the operators considered justifiable, had something to do with the decrease in quality. It may possibly have affected the preparation of coal in a few instances where the operator was forced to reduce his costs as much as possible, but if the Government price were advanced on the present basis of control to $5 per ton at the mines, it would not reduce the percentage of impurities in the coal one iota.

At the time when we should have given attention to conservation of our natural resources, we were wasting large quantities of really marketable coal. But in a crisis like the present war, when we need large quantities of coal in its purest form with the most concentrated heat units, we find the miners are loading all of the high-ash coal, bone and in many cases, slate, rock and sulphur balls with practically no effort on the part of the operator to stop them. In fact, most of the picking tables and coal washers have been discontinued and the entire product of coal with its impurities goes to market unchecked. In some cases the operator is loading the gob pile, the culm bank, coal from the poorer parts of his mine, or is concentrating his production on the mines of poorest quality, for he knows that under present conditions anything will go, and he is reserving the better quality of coal for future needs when strong competition is resumed.

There has been a time, and there will again come a time, when conservation of our coal supply should be carefully considered in connection with the preparation of coal for a competing market, but now is not the time to conserve our national resources. Today, when every ounce of heat energy, every railroad car and every locomotive should be producing maximum results, one thing above all others should claim the attention of the men of this country, and that is to distribute coal in its purest form to the consumer and obtain maximum efficiency in its combustion. Instead of doing that, we are clogging our railroads and furnaces with the dirtiest and poorest quality of coal ever produced.

What Is the Remedy?

To simply appeal to the coal operators and miners on the grounds of patriotism will not accomplish the results. We must go to the very root of the matter, and during the present crisis eliminate every possible pound of slate and impurity from the coal as it is loaded into the railroad cars at the mines. This will be equivalent to increasing the motive power, the car supply and terminal facilities of our railroads to the extent of 30,000,000 tons carrying capacity per year. It is possible; it can be done; and it *must* be done. The question remains how to do it most quickly and at least expense.

You must bear in mind that increasing the price alone will *not* improve the quality, and without the quality being improved the railroads cannot haul the necessary heat units. There is enough labor available at the mines to clean the coal; our trouble is due to lack of railroad facilities to haul the excessive amount of impurities it contains. It seems so perfectly self-evident that we must put forth every effort to concentrate as many heat units in each ton of coal which our railroads can handle, that in the face of these figures we can go to any end in carrying out the remedy. This question is important enough to do the job right and anything which is worth while *can be done.*

Pay Price in Proportion to Quality

I would recommend that the Government establish coal-sampling stations at certain points where large numbers of railroad cars are unloaded to vessels or power houses. These sampling stations should be equipped with the necessary machinery for handling samples of one thousand pounds or more so that the sample will be thoroughly representative

of the individual car from which it is taken. From this sample determine the percentage of total ash as well as the free impurities (slate, rock, etc.) so that a positive check will be obtained on each mine as to the quality of coal being produced, and the effectiveness of its preparation.

By locating these sampling plants at such points as New York, Philadelphia, Baltimore, Hampton Roads, Cincinnati, Lorain, Buffalo and other lake loading ports, adding Chicago, St. Louis, Indianapolis, Birmingham and other cities throughout the United States later on as the work is extended, coal from every mine in the adjacent districts can be consigned or reconsigned by the Fuel Administration to these cities and to these particular piers and power plants so that at least one sample each month will be obtained from every mine shipping coal. Later on as the system is perfected it could be increased to the sampling of one car out of every ten shipped, so that a very fair average of the quality of coal loaded from each mine would be obtained. Even though not enough cars could be sampled to get an average that would be scientifically accurate to a fraction of one per cent., the influence on the operator and miner would be effective.

To give the coal operator a real incentive to clean his coal as he should, the price he receives should be materially affected by the quality of coal produced. It would be advisable to go a step farther and base the distribution of cars to the mines on quality also. The quality as shown by the results of one month should form the basis of price and car distribution for the subsequent month, so that no confusion resulting from back charges and adjustments need interfere with the plan.

The adjustment of price for variations in intrinsic ash should be nominal, say 5 or 10c. per ton, but for extraneous ash it must be severe, such as 25 to 50c. per ton for each 1 per cent. ash.

The base price for standard quality of coal should be established by the Government as at present, with possibly different base prices and different quality standards for the several districts, taking into account the character of coal, height of seam and other mining conditions, but the main thing to strive for is to obtain the highest quality of coal and the most concentrated form of heat units in order to tide us over the coming year, which is going to be much more critical than that just past, unless some radical step is taken to apply a remedy for the basic cause of the present situation.

This work of sampling and accurate quality determination should be supplemented with Government inspection at the mines to prevent the loading of bad crop coal and to keep in first-hand touch with the mining conditions as a supplemental check upon the preparation of coal and to instill a spirit of coöperation.

Real knowledge of the quality of coal being produced will also be of great benefit in classifying coal from various mines into the different pools so the consumer, and particularly the railroads, will receive coal of uniform quality, thereby enabling them to obtain maximum capacity and efficiency from the coal they use.

The Remedy Is Feasible

There may be some people pessimistic enough to say that this scheme cannot be carried out, it would cost too much money or we cannot get the men to do it; but this question is of such basic importance today that some remedy is absolutely necessary. We have our choice of either building thousands of locomotives, a hundred thousand railroad cars and adding to the terminal facilities of our railroads within the next few months to haul this 30,000,000 or more tons of dirt, or asking the railroads to ship only the most concentrated form of heat units in coal of highest quality.

The latter can be done, the remedy is feasible and practical, it can be started immediately and put into effective operation within a few months at a trivial cost as compared with any other remedy available. The Government already has departments familiar with every problem which enters into the carrying out of this scheme. It would require many competent technical men to carry it out, such men as you, who are being turned out of our colleges and universities today, and those who have preceded you during the past few years.

In normal times, when competition was strong, the consumer could get about what he wanted at a very low price, but now in his anxiety to get coal he has catered to the coal man, forgotten quality, paid any price, and has been satisfied to take whatever the coal man gave. Today we hear more talk of quality from the coal operators, who want the quality considered as a basis of price, as a basis of car distribution, as a basis of classifying coal into different pools, than we have heard from the consumer. But the operators seem to think that it is sufficient to classify the coal very roughly, using quality data obtained prior to present conditions. This would help some, but it is not the real remedy that must be put into effect today, for it must be based on the quality of coal *now* being produced.

The engineers of this country, who are responsible for efficiency in the combustion of coal, should also make a very thorough search into the actual conditions which exist in the plants under their care. One of the difficulties is that combustion has been discussed and rehashed so many times and they have been warned about excess air, unburned gas, CO_2 and various other things until it is a good deal like the boy and the wolf. They know so well what ought to be done that they begin to think they are actually doing it. Others know they have done it once and assume that the men in their plant are continuing to do it without constant supervision or checking up, but everyone who is at all familiar with the combustion of coal knows that there is room for decided improvement along this line in a majority of power plants, including many of the larger central stations in operation today.

One of the basic difficulties is, the person responsible for the operation of the plant does not always know exactly what results he is getting. If he is basing the results on coal per kilowatt, coal per unit product, such as steel, paper, cloth, etc., or even pounds of water evaporated per pound of coal, he does not have as close a check upon his efficiency as he should have, because he is likely to blame poor results to the inferior quality and varying character of the coal he has received. To a large extent the coal has been responsible. The decrease in quality has taken his heart out of his work so far as striving for high efficiency is concerned, and I have even heard some prominent engineers make the remark that they did not care a rap about efficiency—what they wanted was coal that would give them capacity. They apparently forgot that when they are getting efficiency they are also getting capacity, for wasted heat units can accomplish nothing. Efficiency and total plant capacity go hand in hand. We must stretch every ton of coal out to last as long as possible.

Let us forget for a minute much of the detailed theory and ideas of combustion and come down to a few basic facts. Coal is fired to the boiler furnaces to produce heat. Whatever the heating value of this coal may be, whether it is 10,000 or 14,000 B.t.u. per pound, that figure represents 100 per cent. of the heat units available for making steam in that boiler. The problem is to transfer as many heat units as possible from the coal to the steam. All of this heat cannot be utilized, but it does all show up some place, and the channels through which this heat passes may be divided into three general classes:

		Best Practice, Per Cent.	Probable Average, Per Cent.
1	Incomplete combustion (loss)	2	7
2	Heating up flue gases and other things beside water in in boiler (loss)	18	28
3	Evaporating water in the boiler (useful)	80	65
	Total heat in coal as fired	100	100

The entire 100 per cent. of heat, no more and no less, always shows up in these three main items, which may be called a heat balance.

The amount of heat in the third item represents boiler efficiency, and it must be low if the other two items are high and it can be high only by keeping the other items low. These two loss items are such that they get first chance, so to speak, at the heat units in the coal, and high boiler efficiency can be assured only by knowing what are these controllable losses and how to keep them at a minimum.

The first item, incomplete combustion, covers unburned coal and coke carried away in the ashes. This is a loss that can readily be observed by inspection and checked up by sam-

pling the ashes and determining the percentage of combustible. The other loss under this item is unburned gas, principally carbon monoxide (CO), which is due to carrying too thick a fire and operating the furnace like a gas producer. This loss can be obviated by carrying a thinner fire and providing a greater supply of air per pound of combustible. If this is carried to an extreme, too much air passes through the furnace and carries away large quantities of heat at flue-gas temperature, thereby increasing a loss which would come under the second item. It is, therefore, necessary for the fireman to have some guide in maintaining the fuel bed in the proper condition so as to obviate the unburned-gas loss on the one hand and the excess-air loss on the other.

The most usual means of checking up this condition has been flue-gas analysis, and engineers should apply their knowledge of this subject to actual practice today as never before. There are other means that serve as a very valuable guide, such as the relation between the rate at which air is supplied for combustion and the rate at which steam is generated from this combustion. This is based on the fact that air is a fuel just as much as coal, and a certain evaporation should be obtained per pound of air. This is practically independent of the quality or character of fuel.

Watch the Appearance of the Flame

Another method, which is within the reach of every fireman and every engineer in the country without buying a cent's worth of equipment, is to watch the appearance of the flame from the furnace. The critical points to watch are the top of the first pass in a cross-baffled water-tube boiler; the point where the gases enter the tubes at the rear of a return-tubular boiler, or the corresponding location in boilers of other types. When there is too little air for complete combustion a flame of burning CO gas is visible at these points. Oftentimes it reaches entirely through the boiler and escapes before combustion is complete. A large loss due to unburned gas may result even though this flame may extend only part way through the tubes of a return-tubular boiler, or only start down through the second pass of a water-tube boiler, for the gases are cooled below their ignition temperature before combustion is complete. On the other hand, if too much air is supplied to the furnace, observations at these points will show no flame at all. The most efficient conditions exist when there is a good mellow flame ending at about these points in the gas passage. This shows that there is air enough for complete combustion, but not much loss due to excess air. The latter loss may be very great when the flame is too short. In many metallurgical furnaces the appearance of the flame is the principal guide in controlling combustion.

At the same time that the engineer and fireman are looking into the gas passages of their boiler, studying the appearance of the flame, many of them will be surprised to find how dirty are the tubes and how many holes there are in the baffles of their water-tube boilers. These conditions are much more prevalent, even in the largest power plants, than is generally supposed or admitted. Both conditions result in a high temperature of gases escaping from the boiler and materially increase the loss in the second item previously mentioned. It pays big to keep boiler tubes clean and maintain baffles in good repair, even when coal is at normal price and there is plenty to be had; but now it is a crime to overlook conditions that can be so easily remedied and produce returns of such magnitude and importance.

Knowledge and Eternal Vigilance

In connection with the operation of power plants there are two old quotations that exactly fit, and I urge everyone to bear them in mind in connection with their own plant. The first one, "Knowledge is power," is certainly applicable. You *must know* what your plant is doing, you must know what is the efficiency of your boilers and furnaces, what and how much your losses are before intelligent steps can be taken to apply remedies. If you simply know that the efficiency is poor, you cannot improve it until you know why it is poor. If there are big losses in the first item of the heat balance mentioned, you should do one thing. If they are in the second item, you should apply some other remedy.

The other quotation, "Eternal vigilance is the price of economy," is equally pertinent. Many people have spent much time and money making an extensive series of tests in their power plants, and by means of such tests obtained very good evaporation and high efficiencies which pleased them greatly. The results were tabulated for blueprints or framed in their office, and many of them are foolish enough to think that their plant is still producing this kind of results. Some of them are, and some of them are getting even better results today than they were during such tests, but this applies only to those who are using eternal vigilance and checking up their efficiencies as well as their losses from day to day and hour to hour. As George Diman says, "A boiler test is a good deal like a horse race—you can get most anything you want out of it, but you keep on burning coal 365 days of the year."

Importance of the Coal Industry

The things which have happened during the last year in connection with the coal industry have served to waken the engineers as well as the general public to the importance and magnitude of the coal problem. It not only needs the most careful attention and the most diligent study today, but it needs the continued service of the technically trained men of this country to follow it up in the future, for it always will be a problem of the greatest magnitude in the United States. We have been bountifully supplied with hundreds of thousands of acres of coal of good quality; we have been mining it so cheaply and thinking so little of the future that most people have not realized what tremendous problems were involved and how important they were to the industrial and physical welfare of the country.

One of the most important problems is the relation between the price and value of coal. This has not yet been satisfactorily or equitably determined, for it involves a third factor—conservation of our natural resources which should enter into this relation, and the working out of this phase of the coal problem alone will require a great deal of attention by the best brains of the country.

Another illustration of a single phase of the coal problem which is deserving of further attention is the simple question of storage. This always has been a serious problem, especially for certain coals when stored in certain parts of the country. Following the war it is going to be more so, because people who have been handicapped now are going to store larger quantities of coal as soon as they are able to get coal to store, but what is the use of storing if they are unable to prevent expensive losses due to spontaneous combustion?

I therefore urge you students of the Johns Hopkins University and young men from other schools to give the coal problem in its various phases your most earnest consideration in selecting your life work or at least your first job, because there is no more important problem today, and there is no richer field for the future, than to tackle some phase of this important industry and bring to light and establish as facts many of the traditions that have been drifting along for so many years without knowledge as to their control and application in normal times, or even in emergencies like that of the present day.

The problems that concern us most are those of the immediate future. Are we going to have coal enough to see us through the coming winter? The present indications are that unless some radical steps are taken immediately, the coal shortage will be much worse than it has been. To be satisfied with preferential shipments and permit many of our basic industries to close down is to be a quitter, when by concentrating our efforts on loading clean coal at the mines and improving the efficiency of its combustion in furnaces we can have ample coal for all, thereby helping instead of hindering the Thrift Campaign.

We have heard the argument that we should be patriotic and be content with inferior coal, old culm banks and other refuse fuel the same as we are with wheat substitutes in our bread. But the food and fuel problems are very different. Economy in their use applies equally to both, but the neck of the bottle of the food question is production, while the weakest link of the coal problem is transportation. It is a crime to burden our railroads with hauling dirt when it is within our power to ship clean coal and supply heat units in their most concentrated form.

Boiler Explosion at East Chicago Kills Seven

At 10:15 p.m., on Feb. 18, a most unfortunate boiler explosion occurred at the Inland works of the Republic Iron and Steel Co., East Chicago, Ind. A total of 43 men were victims of the accident. Two were killed instantly, two died in the hospital soon after, and in the course of a few days three more succumbed to their injuries. Of the others ten were wounded seriously. At the time of writing they were still in the hospital but on the road to recovery. The remainder, for the most part, received minor injuries requiring only first-aid dressing. As an explanation of the excessive casualty list, it may be stated that at the time of the accident a number of men were sitting in their favorite gathering place in the vicinity of the boiler, eating lunch. Near-by, others were transferring a truckload of material from the mills. Scalding from hot water issuing from a broken feed line on an adjacent boiler and flying brick from the setting of the ruptured boiler were the sources of injury.

The boiler was of the Cook vertical water-tube type, rated at 250 hp. It had been installed in 1901 as a waste-heat boiler, taking the gases from a furnace serving a 16-in. bar mill. With a similar outfit it occupied a sheet-steel building measuring 65 x 140 ft. About three years ago the two furnaces were removed, but the boilers were retained, equipped with dutch-oven furnaces provided with hand-fired grates and used as auxiliary units to help out with steam on large orders and to furnish a necessary supply on Sundays, holidays and at times when the furnaces and their respective waste-heat boilers were down. In other words, the boilers were subject to intermittent service, being fired up and allowed to cool off frequently in the course of a month.

Including the two auxiliary boilers just mentioned, the plant contained a total of 18 vertical water-tube boilers, 11 rated at 125 hp. and 7 having double this capacity. As previously intimated, 16 are waste-heat boilers, each being located in proximity to its respective furnace. All feed into a common steam line supplying the engines of the mill. The pressure on this line, depending upon the number of furnaces and waste-heat boilers in service, the condition of each and the demand of the engines, varies from 70 to 125 lb., the latter pressure being the maximum allowed for safe operation. A chart from a recording gage on the steam line showed that the pressure had run through this range on Monday, the day of the accident. At the time of the explosion seven boilers were in service and the pressure on the line was 70 lb. The ruptured boiler had been cut out of service Saturday on account of two leaky tubes. These tubes had been replaced on Sunday, and the boiler filled with water. One hour before the explosion the boiler had been fired up cold, and within this period the pressure had built up to 50 lb. Both the engineer in charge and the water tender had looked at the gage just before the explosion, as they were intending to "cut in" the boiler on the line when the pressures equalized.

Without any preliminary indication the boiler exploded, the brick walls of the setting spreading out and the top drum with the tubes rising through the roof and landing about 50 ft. distant on the side opposite from the furnace. The roof was damaged badly and the whole side of the building blown out, the property loss approximating $20,000. The lower drum and the tube sheet remained on the foundation.

The steel stack connecting with the boiler through a cone-shaped breeching, was propelled 75 ft. in the opposite direction. The guy wires apparently turned it top down, and in this position it cut through a box-car half filled with firebrick, coming to rest on an axle of one of the end trucks and remaining in that position as shown in the general view. The boiler steam pipe was ruptured between the valve and the main steam line, and a length was broken out of the latter, so that steam from the other boilers rushed out of the ruptured ends. Within three minutes the pressure was down on the whole plant, but before the other boilers could be emptied completely, hand-operated valves in the line beyond the ruptured points were closed. With the line located about 40 ft. above the floor and the building open, it is felt that steam issuing from the header did not contribute to the suffering of the injured. Those scalded were in line with a stream of hot water forced from an adjacent boiler and this was the cause of at least half the injuries. A 2½-in. feed pipe leading into the bottom drum of this boiler had been ruptured by the explosion.

FIG. 1. GENERAL VIEW OF WRECKED BUILDING; STACK STICKING IN BOX-CAR IN BACKGROUND

As the Cook boiler, formerly built by the McNeil Boiler Co., of Akron, Ohio, is no longer made, it may be well to review its construction. The boiler under discussion consisted of an upper steam drum and a lower mud drum connected by a 14-in. central flue and 120 No. 10 gage seamless Shelby tubes 4 in. in diameter and 20 ft. long. The tubes extended through the sheets and were rolled and belled to

make tight joints. The drums were 80 in. in diameter, the top drum being 7 ft. deep and the lower drum 44 in. The vertical seam was double-butt-strapped triple-riveted, having a computed efficiency of 85.8 per cent. The metal of the crowned heads was ⅞ in. thick, the shell plates ⅝ in. and the tube sheets ¾ in. At either end the central flue was riveted to a flanged portion of the tube sheet, turning into the drum in each case. In addition eight 1¼-in. round stays tie the flue to the crowned head of the steam drum and six 2½ x ½-in. flat braces secure it to the lower head.

FIG. 2. LOWER DRUM, SHOWING THE RAISED TUBE SHEET

The tube sheets were also tied to the heads by evenly spaced 2 x ½-in. double-strap stays, six having been placed in the upper drum and eight in the mud drum.

In this particular boiler water was fed into the steam drum. The circulation was down through the central flue and up through the tubes. The gases from the furnace made one pass along the tubes and around the upper drum into the conical outlet to the stack. The boiler had a full brick setting. It was equipped with two 3½-in. pop safety valves in good working order. Manholes in both drums were provided to afford access for inspection and repairs. From the outside it is difficult to inspect the central flue. A subsequent inspection of this part of a duplicate boiler required the cutting away of 20 tubes.

An inspection of the damaged boiler revealed no defect in the top drum or in the tubes. The stays in this drum were twisted, and one of them had been broken as a result of the explosion. The central flue was intact, but had been buckled slightly near the center, a natural result if the bottom of the flue first struck the ground. In the lower drum the central flanged portion of the tube sheet had been torn off and the sheet pulled up at the center to form a convex surface having about the same radius as the head of the drum. The joint attaching the sheet to the circular wall of the drum held fast. All the stays were broken. Ir four of the flue braces the crowfeet at the bottom were ruptured. In the other two the break was near the top of the stay, the riveted end remaining intact in each case. With one exception the flat double stays supporting the tube sheet broke at the top.

Nearly all the breaks in these stays gave evidence of some crystallization, but not sufficient to materially lessen the strength. Notwithstanding the long service there was no evidence of corrosion in the boiler. The metal was clean and free of scale. Two years previously, the boiler had been entirely retubed and 20 new tubes had been put in place Christmas week. On Jan. 20 an insurance inspection revealed no defects. Cracks or any visible cause of weakness would probably have been discovered at that time. On account of coal shortage the boiler had not been fired more than ten times since the inspection.

A review of the case would indicate that the initial rupture occurred at the knuckle of the central flange of the lower tube sheet. As will be remembered, this was broken away and could not be found after the explosion. The 21 rivets of $1\frac{3}{8}$-in. diameter holding it to the flue were greatly elongated, in some cases the reduction in area being 75 per cent. The conditions under which the boiler operated were favorable to induce failure at this point. As previously stated, the boiler was in irregular service, being fired up and cooled off frequently. Before the explosion it is evident that the boiler must have been forced to raise a pressure of 50 lb. from cold water in one hour. For a boiler of this type three or four hours would have been better. With no baffle to guide the flame, the intense heat from the furnace would strike the tubes on the furnace side and the

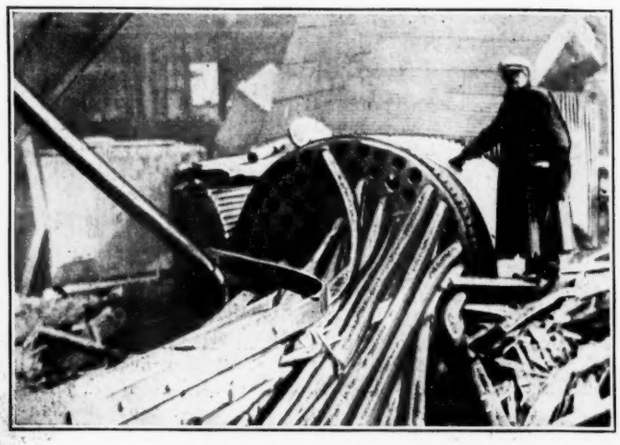


FIG. 3. UPPER DRUM AND TUBES SHORTLY AFTER THE EXPLOSION

front of the central flue, leaving the other half of the flue and the rear tubes comparatively cold until proper circulation had been established. This would create expansion on the furnace side of the boiler and tend to tilt it away from the fire. In a boiler of this type after being used for a short time, the tubes will warp to a certain extent and will have little holding power until straightened out. Consequently much of the stress would be thrown on the central

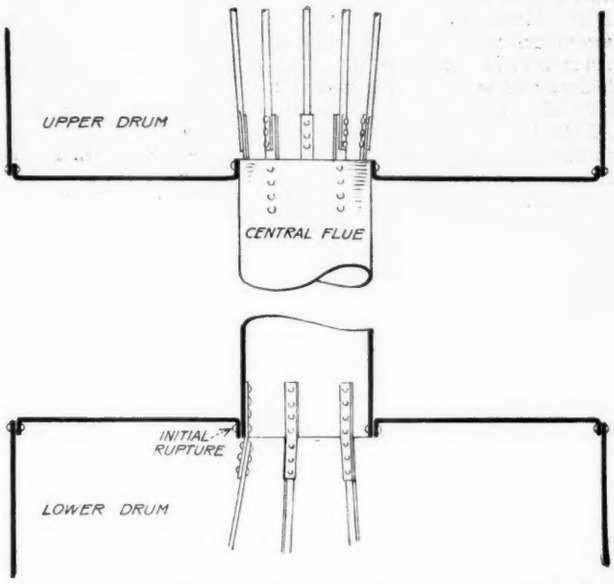


FIG. 4. VERTICAL SECTION THROUGH BOILER, SHOWING FLUE BRACING AND POINT OF INITIAL RUPTURE

flue and with the tilting action previously mentioned the strain on the lower flange would be particularly severe, tending to weaken and crystallize the metal in the flange. It is quite probable that during the hard firing a crack developed at the knuckle of the flange on the furnace side and followed around until the metal weakened enough to let go. This would release the pressure, the water in the

boiler would flash into steam and in rushing down the central flue would produce a skyrocket effect that would be irresistible. Coming suddenly, this force snapped all of the lower stays, pulled the tubes out of the sheet and, in doing so, raised the sheet itself as previously described, the upper drum and tubes shooting upward and landing some 50 ft. away.

Other theories have been advanced. For example, the unequal expansion might have snapped the tube-sheet braces on the furnace side and so weakened the holding power that the explosion resulted. The boiler in this case would have been propelled away from the furnace, and this is the direction in which it did go. The evidence, however, favors the theory first advanced, and if this is correct, the central flue was an undesirable element in the boiler design. It appropriated much of the stress created by expansion, acted as a powerful lever on the long range and centered the holding power in one element rather than in the 120 tubes of the boilers.

Chicago Section A. S. M. E. Discusses Coal Situation

On Mar. 1 at the La Salle Hotel, the Chicago Section of the American Society of Mechanical Engineers held its second dinner meeting of the season. The topic was "The Coal Situation." Prof. H. H. Stoek, head of the Mining Department, University of Illinois, and chairman of the Conservation Committee of the Fuel Administration for Illinois, and Joseph Harrington, also a member of the committee, were the speakers. Prof. A. N. Talbot, the newly elected president of the American Society of Civil Engineers, was present and in response to an invitation from the chairman made a few remarks upon the present need for coöperation among engineers. The recent decision of the civil engineers to take quartrs in the Engineering Societies' Building, he said, was a step in advance and it was his opinion that it would result in close and united effort of the various engineering bodies.

Joseph Harrington, who was called upon to open the topic of the evening, said that it was not his object to reiterate the familiar phrases in regard to the character and extent of heat losses, assuming that the body of engineers present were familiar with these details. With engineers of experience it is not so much a question of what constitutes efficiency or wherein the losses occur, as it is to apply the knowledge of efficiency measures from both the physical and the human viewpoint. The efficiency of a boiler plant depends on the inherent efficiency of the equipment and the efficiency of the operatives in using this equipment.

Mr. Harrington contended strongly that efficient apparatus must be provided. While intelligent operation serves to overcome to a certain extent the deficiencies of the equipment, it is not adequate to offset old worn-out inefficient apparatus, and it is a matter of mathematics to demonstrate the wisdom of scrapping old equipment and providing modern machinery in its place. As to the efficiency of operation, this depends on the intelligence and interest of the operating force. These, in turn, must be supplemented by adequate instruments and a general record of observations. Granting that all of the foregoing is understood and applicable in such instances where both the will and the money are available, the question still remains, how to apply this knowledge in the universal manner necessary to have any practical effect on the coal consumption of the entire country.

Two general methods appear—the educational, or patriotic, and the autocratic, or compulsory. The former method is that which is now being attempted by the conservation department of the Fuel Administration, and in spite of every effort it is almost impossible to reach all coal consumers. It would mean the education of millions, and the outlook is more or less discouraging to those who see the necessity of conservation for the immediate future. This method, however, is necessary and satisfactory as far as it goes. It is applicable to the larger plants having the more intelligent type of engineer and sufficient capital for proper equipment.

It was Mr. Harrington's belief, however, that the educational method must be supplemented more or less by the autocratic method. Recognizing the painful fact that every coal consumer in the country has not yet reached the point where he is willing to forego some of his own peculiar advantages for the sake of the public, there seems to be a necessity for some Governmental agency endowed with power to step into a man's plant and, after an intelligent examination of the situation, set forth imperatively the needs of such a plant. Care would have to be exercised and it would probably be necessary to have some organization or clearing house composed of a body of fair-minded, intelligent and experienced combustion engineers to which appeal could be taken in case any owner was dissatisfied with the requirements laid down by the inspector. There are so many cases wherein the conditions call loudly for simple remedies that it is more than likely that great good could thus be accomplished. Mr. Harrington closed by stating that he advocated a country-wide application of compulsory measures through state committees and all acting through a central clearing house such as the United States Bureau of Mines or some specially created body. As in the case of the enforcement of smoke ordinances, it is more than probable that compulsion would be required only in the exceptional cases. The mere fact that there was such a body competent to prescribe measures and insist upon enforcement would go a long way in inducing plant owners to spend their money for conservation measures. The only attractive feature of the whole program is that money thus spent reacts immediately to the advantage of the owner.

Coal Output Hampered by War Conditions

Professor Stoek reviewed the coal situation in war times. He showed how coal is related to everything connected with war and how badly it is needed to carry the war to a successful conclusion. The United States uses more coal per capita than any other nation, and as we have more of it, many might wonder why enough could not be obtained to meet all needs. In 1913 the coal production of the world was 1,478,000,000 tons. Of this the United States produced 570 million tons and Great Britain 322. In 1914 the production in Great Britain fell to 262 million tons, to 252 in 1915 and to 256 in 1916. Consequently the coal output in that country suffered as a result of the war. It would be reasonable to expect that there might be a similar falling off in this country.

The speaker briefly reviewed the coal resources of the Allies. All of the Belgian mines and most of the French mines are in the hands of the enemy. Italy needs 1,000,000 tons of American coal per month. Russia is a negligible quantity as far as the coal situation is concerned, and of the neutrals Holland and Switzerland are particularly scarce of coal.

Now that the immediate shortage is over, there is no occasion to feel too optimistic. The conditions producing last season's shortage are still with us, and there is little hope to increase the output. Conditions next winter may be even worse, unless large economies are effected.

In 1916 the output of coal in this country was 600,000,000 tons. To maintain the normal increase of 10 per cent. a year would call for an increased production of 60,000,000 tons. This would mean the opening of fifty new mines of the largest size or greatly increased capacity in existing mines. It would also mean a 10 per cent. increase in the 700,000 men employed last year, or 70,000 new men. With a decreasing labor supply the chance of increasing the output of present mines is small. New mines would require enormous capital investments and with slow deliveries new equipment could hardly be obtained in time to do much good. It would look as though all will have to make the best of it and get results by economizing as much as possible.

Professor Stoek reviewed the causes leading up to the coal shortage. The enormous demand, the high prices in effect last June, the attempted reorganization in Washington on the Peabody plan, the rumor of cheaper coal delaying its purchase and the final fixing of the price by the present Fuel Administration were all mentioned. When the

busy transportation season in the fall arrived, there was a great shortage of coal and the unusually cold weather handicapped transportation. In addition there was a shortage of coal cars. To keep pace with the usual 10 per cent. increase in coal requires new cars in the same proportion. The increase in cars last year was only 4 per cent., and although the average time for the return trip of a coal car, 30 days, was reduced, there was not a sufficient number to meet the demand. A number of experiments such as pooling, revolutionized present methods and temporarily resulted in disorganization. In addition far too much waste material was shipped with the coal. The 50,000,000 increase in tonnage was counteracted by three times the quantity of dirt, slate and ash. Lack of coal was not due to export. We sent almost a negligible quantity to France.

The severe fuel restrictions imposed in Europe were reviewed and in conclusion the ways of saving coal proposed by our Fuel Administration, such as lightless nights, curtailing the schedule of electric roads, changing the running time, lessening the temperature in the cars, the skip-stop plan and coöperation of all employees. Many of these regulations were put into effect and resulted in saving. It is hard to make the consumer realize the enormous increase in demand and that his little saving with numerous other comparatively small savings made in reality a large aggregate. Efforts are being made to get in the hands of those using fuel, literature dealing with conservation and care in operation, not only in the power plant and the railway locomotive, but in the home as well.

With the railway facilities taken up, storage will not greatly augment the annual supply, but to relieve the situation it is evident that as much coal as possible should be obtained before the fall rush. Storing can be safely done if care is used to separate the fine from the coarse coal and to keep the pile away from external heat. Fine coal must have very little air or an abundance of air to carry away the heat of oxidation. When heat does show it is necessary to move the pile to cool it. With the difficulty of moving eliminated, high piles are just as safe as low ones, the burning generally starting near the surface and frequently at the top of the pile. Storage of screenings is risky unless under water. When storing in basements, the coal should never be drenched with water.

The discussion turned to storage, the possibility of large savings by the railways, which use one-quarter of the entire coal supply, and in the power-plant supervision over improvements that would effect economy. It is important to get a better grade of firemen and make the pay commensurate with the saving.

In conclusion it was strongly emphasized that as the coal production cannot be greatly increased, all must save—the railways, the industrial plant and heating in all buildings and the home. It is everybody's problem—the man at the mine, transportation and the consumer. All should be impressed with the need of saving and with the fact that if each "does his bit" it will tend to relieve the situation next winter.

Increase in Electric Rates

Public utilities commissions throughout the country are wrestling with the question of increased rates asked for by electric-light companies, which maintain that they are losing money under the present rates. It is not clear, however, as to whether the losses are based upon the falling off of revenue below actual operating expenses or are based upon lesser profits as compared with those before the beginning of the war. These increases in rates are considered by many of the users as being excessive and are being fought.

In the City of Mobile, Ala., the Mobile Electric Co. is desirous of increasing its present rates, which, according to the contract of Dec. 31, 1906, should remain in force perpetually. On Dec. 26, 1917, the city and the electric company entered into another contract for municipal lighting, which contains the provision that the electric company shall furnish customers with current on a meter basis at its regular schedule of rates. The rates under the perpetual contract are as follows: From 0 to 50 kw.-hr. per month inclusive, 10c. per kw.-hr.; from 51 to 150 kw.-hr. inclusive, 9c. per kw.-hr; from 151 to 300 kw.-hr. per month inclusive, 8c.; from 301 to 500 kw.-hr. inclusive, 7c. per kw.-hr.; from 501 to 1000 kw.-hr. inclusive, 6½c.

A discount of 2c. per kw.-hr. to be allowed if bills are paid within ten days after rendered, except that during the ten years of this contract the rate mentioned from 0 to 50 shall be 10c. per kw.-hr. less a discount of 3c. per kw.-hr. if paid within ten days after the rendering of the bill. All over 1000 kw.-hr. special contract. The minimum charge per customer is to be $1.25 per month less 25c. if paid within ten days after the bill has been rendered.

The proposed increased rates, to take effect Mar. 1, 1918, are as follows: First 50 kw.-hr. per month at 10c. per kw.-hr.; next 50 kw.-hr. at 9c.; next 100 kw.-hr. at 8c.; next 300 kw.-hr. at 7c.; next 1500 kw.-hr. at 6c.; excess kw.-hr. per month at 5c. per kw.-hr.

Prompt payment discount 10 per cent.

Minimum bill, $1 net per meter per month.

Legal steps have been taken to prevent the enforcement of the proposed increase in rates.

Another instance is that of the Wilmington & Philadelphia Traction Co., which has asked the public utility commission for permission to raise its rates. At the hearing it was brought out that the big users of electricity are willing to pay the proposed increase, but there are those who are opposed to an increase to the consumer for the lighting of homes.

The increase of rates was protested on the ground that the actual cost of production of current, even under present conditions, does not warrant it; that the actual cost now is at least 50 per cent. below the price that the company is receiving for the current; that the plant and equipment are sufficient to supply local needs, and that the abnormal demand for current is due almost exclusively to contracts with outside parties. Other objections were also brought to the foreground.

The proposed new schedule for electric current rates is as follows:

Lighting Rate: First 75 kw.-hr. used per month, 9½c. per kw.-hr.; next 150 kw.-hr., 8c.; next 175 kw.-hr., 7c.; all over 400 kw.-hr. used per month, 6c.

Minimum monthly service charge, for residence, 50c. per meter; for business, $1 per meter; 5 per cent. discount for cash on bills exceeding the minimum amounts when paid within 10 days from date of bill.

Retail Power: First 100 kw.-hr. used per month, 8½c. per kw.-hr.; next 100 kw.hr., 8c.; next 100 kw.-hr., 7c.; next 300 kw.-hr., 6c.; next 400 kw.-hr., 5c.; next 3000 kw.-hr., 4c.; next 26,000 kw.-hr., 3c.; all over 30,000 kw.-hr. used per month, 2½c. per kw.-hr.

Minimum monthly service charge, $1 per hp. for the first 10 hp., 75c. per hp. for the next 10 hp., 50c. per hp. for all over 20 hp.

No minimum less than $3 for direct-current or single-phase alternating; nor $5 for three-phase alternating; 5 per cent. discount for cash on bills exceeding the minimum amounts when paid within 10 days from date of bill.

High-Voltage Wholesale Power: First 50,000 kw.-hr. used per month, $0.02 per kw.-hr.; next 50,000, $0.019 per kw.-hr.; next 50,000 kw.-hr.. $0.018 per kw.-hr.; all over 150,000 kw.-hr. used per month, $0.017 per kw.-hr.

In addition to the charges as per foregoing schedule add 25-100 of one mill for each 10c. of increase of cost of coal delivered at power plant in excess of $3.05 per long ton. Guarantee 50,000 kw.-hr. per month. Prices are net. Current metered at primary voltage.

That the central stations have been hard hit by the coal shortage this winter is well known. Some of the heating companies have been hit by the ruling of the public service commissions. For instance, the Kansas City Light and Power Co. has had its rates reduced from those which existed last August. The company claims that it lost $57,000 during the last three months of 1917 under the August rates and estimates that its loss under the new rate just fixed by the commission would have been at least $75,000.

The new rate is as follows: First 20,000 lb. of condensation, 85c. per 1000 lb.; next 180,000 lb., 70c.; next 500,000 lb., 60c.; all over 700,000 lb., 50c.; minimum on buildings, $5 a month from Oct. 1 to June 1; minimum for water heating and other purposes, $5 per month for 12 months.

Although it is said that the company is considering dismantling its $1,500,000 heating plant and quitting the heating business, it is doubtful that such a step will be carried out.

With the increase in rates sought by the central stations and the curtailment of power from time to time, the position of the isolated plants has been strengthened in that they have in most instances been able to operate, while neighboring plants depending upon central station service have suffered from more or less interrupted service.

Abandoning Isolated Plants in Favor of Central-Station Power

A public hearing was held on the afternoon of Mar. 4, before the Public Service Commission of New York, to obtain information as to whether coal could not be saved by the closing up of many small private plants and the substitution of electrical power generated in large central stations. Representatives of the United States Fuel Administration attended the hearing, as the question is one in which Dr. Garfield is vitally interested.

J. W. Lieb, vice-president and general manager of the New York Edison Co., repeated the statement he had made at an earlier hearing, that the shutting down of some 650 small steam-power plants in Manhattan and the Bronx and the taking over of their power business by the large central station would result in a saving of 500,000 tons of coal a year, as a conservative estimate. He based these figures on the savings obtained in the cases of sixty isolated plants that had been closed up in 1917 and that were now purchasing current from the New York Edison Co.

Mr. Lieb cited several instances, covering office and loft buildings, apartment houses and the like, in which the change from private-plant to central-station service had produced savings in coal consumption ranging from 19.8 per cent. to 60 per cent. When asked to name one or more of these instances specifically, however, Mr. Lieb emphatically refused, on the ground that the data in each case were private matters between the company and its patron, and that the figures could not with propriety be made public.

Inasmuch as the whole purpose—in fact, the sole purpose—of the investigation is to determine whether coal will actually be conserved by the substitution of central-station service for isolated-plant operation, it was a decided disappointment to find Mr. Lieb unwilling to divulge the name of a single one of the plants in which such marvelous savings had been effected. This secretive and sacrosanct attitude of the central-station representative was in marked contrast to the readiness with which the isolated-plant representatives were prepared to show their cost figures and to identify them by naming the plant location in every case.

W. J. Salmon, representing the Apex Leasing Co., stated that his company operated a private plant in which electric current was generated at a cost of 2c. per kw.-hr. The exhaust steam from the engine was used in connection with Turkish baths and heating in the building, and so the engine acted practically as a reducing valve. As a result, their current was obtained at a smaller cost than the Edison Co. would quote.

J. I. Straus testified that at the time R. H. Macy & Co. erected their building the New York Edison Co. was asked to estimate the probable current demand, with the idea of using central-station current. The Edison company's engineers estimated 1,250,000 kw.-hr. per year and quoted a rate of 3c. per kw.-hr. But they refused to accept a contract calling for the payment of $37,500 a year for current used. The reason, so Mr. Straus inferred, was that the estimate was ridiculously low. For, during the first year of operation of the private plant installed by his company, the current consumption was 2,000,000 kw.-hr., and in late years the figure has increased to 4,000,000 kw.-hr.

The testimony offered by Mr. Townsend, of the Hotel Majestic, was illuminating. During a ten-month period just before current was taken from the Edison company, the coal consumption was 5622 tons, costing $21,860. In a similar ten-month period after entering into a contract for central-station current, 5352 tons of coal was used for heating and cooking, at a cost of $26,342, and in addition $14,118 was paid to the Edison company for current. Thus, although there was an apparent decrease of 270 tons in coal consumption, the amount burned at the central station should be taken into account. The total cost was $18,600 greater than before—certainly a very expensive experiment in the use of central-station service.

It is not difficult to see why the owners of small plants are anxious to see this question openly discussed. If it could be proved that the abandonment of small plants in favor of central-station service would save coal, the Fuel Administrator might order the closing of such plants as a fuel-conservation expedient.

In a matter that may involve the sacrifice of costly equipment and the means of livelihood of many employees, there should be no secrecy or evasion. A fair decision as to the correct course to pursue should be based on well-authenticated facts and data, and not on mere estimates based on figures to which access is obtainable by only one party to the controversy, and an interested party at that.

The hearing will be resumed on Monday, Mar. 11.

New England's Shipping Needs

In an international shipping shortage such as the allied countries are now facing, it is difficult to determine what branch of war endeavor should have precedence over others. But with New England mills and factories turning out war supplies for the Allies, valued at billions of dollars, the Massachusetts Fuel Administration feels that it has a right to priority of bottoms at the Southern coal-loading points.

Notwithstanding at the present time 216,200 tons of shipping are engaged in bringing fuel to New England for commercial consumption, there is still a shortage of 115,000 tons of shipping. In other words, says the Boston *News Bureau*, Mr. Storrow has figured that with the threefold increase in industrial activity due to the war, a total of 351,000 tons of shipping must be available for the New England coal-carrying trade or production of essentials must be curtailed.

While the boats turned over to this district the last two days (Feb. 25 and 26) total 21,000 tons, they are still far short of the required amount and are providing only temporary relief to those factories that were verging on shutdown.

Through the western gateways Monday (Feb. 25) a total of 973 cars of both anthracite and bituminous coal were moved into New England. This is the second-best rail movement in a day and approaches the required maximum of rail-coal income of 1000 tons a day. This is for commercial purposes and does not include coal which must be moved by the railroads for their own consumption.

Locally, conditions are greatly improved and dealers' supplies on hand Tuesday morning, Feb. 26, showed an increase of nearly 6000 tons compared with Monday. Officials at the Fuel Administration are sending out warnings that while domestic conditions are more comfortable, all unnecessary use of coal for lighting or heating must still be prevented to keep New England war plants working.

Aviation Section, Signal Corps, Needs Skilled Workers

Ten thousand machinists, mechanics, chauffeurs and other skilled workers are needed at once by the Aviation Section, Signal Corps. The dependence of the air service on the most highly skilled men is being brought out more emphatically with every week of development. Practically 98 men out of every 100 in the service must be skilled in some branch of work.

Men registered in the draft may be inducted into this service by applying to their Local Draft Board. Men not registered may enlist at any Recruiting Office. Further information may be had by applying to the Aid Division, Personal Department, Washington, D. C. In either case they will be sent to San Antonia, Texas, for segregation by trades, followed by a brief course of instruction at the flying fields or at various factories and organized into squadrons mostly for service overseas.

New Publications

STEAM POWER PLANT ENGINEERING—By George F. Gebhardt. Fifth edition, rewritten and reset. Published by John Wiley & Sons, New York. Size, 6 x 9 in.; 1057 pages; 642 illustrations. Price, $4.

Few books are more highly valued among power-plant men than this one, the first edition of which appeared nearly ten years ago. Its wide use is its best commendation, especially when one reflects upon the remarkably rapid development in this field during the last decade. As the author says in the preface to this latest edition: "Revisions in 1909, 1911 and 1913 failed to keep pace with the art, and the task of recording correct practice appeared to be a hopeless one." He puts out the new edition, rewritten in great part, believing that radical changes are not likely to come in the immediate future. He has aimed, therefore, to produce a general work of stability, one which, assumably, he believes will present current practice for some time to come without the frequent editions which events of the past have made necessary. That Mr. Gebhardt is sound in this belief is the opinion of the reviewer. Certainly, no new types of prime movers of such revolutionary character as the steam turbine and "express" stokers and boilers are in sight on the horizon; and as the author has excellently covered these and allied subjects, he likely has put his work in more stable form than it has ever been. A period of refinements in detail and thorough quest of economical performance is now here, and these, as always before, the engineer must get from current journals and add the worth-while data to his loose-leaf notebook which forms a working supplement to a book like the one under review.

The most conspicuous additions to the work are the new chapters on Elementary Thermodynamics, Properties of Steam and the Properties of Dry and Saturated Air. In Chapter XXIV, Supplementary Elementary Thermodynamics of Steam Engine, the author has done a real service to the great number of men who use his book. There is not an integral sign in the chapter, which will gladden the hearts of 98 per cent. of his readers, and that he gets through the Carnot and Rankine cycles without the forbidding "log" will be appreciated by those studious operating men who have mastered, by self-study, the use of letters and symbols in formulas, but have balked at logarithms. The table of properties of saturated steam, which are from Marks and Davis, are well arranged, the pressures selected being such that they cover all but the most unusual found in practice.

No less welcome in this book is Chapter XXV, Supplementary on the Properties of Air—Dry, Saturated and Partially Saturated. Gebhardt has needed this chapter on account of the air problems that in ever-growing numbers confront the engineer in these days of widening application of refrigeration and humidifying processes. Goodenough's air tables, the most widely used, are included in this chapter.

Gebhardt has greatly enlarged upon his treatment of fuels and combustion. Suffice it to say that in this latest edition he has presented the most suitable treatment of these subjects, judged by the needs of power-plant men, that the reviewer has ever found, even in books devoted exclusively to fuels and the theory and chemistry of combustion—the theory and chemistry, mind; not those details of technique of combustion as it must be carried on in boiler furnaces. For these he refers the reader to articles in engineering periodicals, and the references are many.

That part of Chapter II devoted to fuel oil would please more if it had, among the many excellent tables it contains, one giving the equivalent heating values of some of the coals and fuel oils widely used along the Atlantic coast. The value of such a table may be questioned, it is true; but it is useful, and its use will grow, particularly in New England, where fuel oil is said to now displace one million tons of coal yearly.

The reviewer regretted to find that in the sectional views of settings of horizontal return-tubular boilers the shells are shown only 28 in. above the grate. Of course, this is satisfactory for anthracite; but the author would have done well to show these shells at least nearly twice as far above the grate. He owes it to the book to help discourage the installation of these low settings. He does give a whole page to drawings of the Chicago No. 8 setting, which has a wing wall and in which the shell is 36 in. above the grate.

The chapter on stokers is almost wholly descriptive, and the power dump plate is not shown, though brief mention is made of it. There is little or nothing said about clinker grinders as applied to some underfeed stokers, and the reviewer finds no mention of development in cooling the furnace side walls or of the desirability of doing this to avoid clinker accumulating here and seriously affecting the operation of the stoker. Stoker operation is too vital a part of power-plant practice to receive such scant treatment in a book which deals so well with the operation of other power-plant apparatus. But then, no other book, so far as the reviewer knows, covers this subject even half well; so perhaps Mr. Gebhardt should not be too severely criticized for this omission.

There is something familiar about the chart showing the effect of temperature on strength of materials on page 238, and the reviewer thinks Mr. Gebhardt forgot to credit "Power," Feb. 13, 1917, p. 208, for it. But then, he has referred so often to "Power" that this oversight is not serious. The chart was plotted by the reviewer from data obtained from the "Valve World," and Mr. Gebhardt's chart is a reproduction.

The reviewer is sure that the author's many readers will wish he devoted a paragraph or two to the relative advantages of cast iron and steel for economizers, and sketched tendencies in America and Europe in these materials as used in economizers. It is an important part of power-plant practice now that high pressures are "coming in" and safety and long periods of uninterrupted service from boilers are demanded.

That Maurice Leblanc has but recently brought out his multijector (steam jet) air pump probably accounts for the lack of reference to it in the chapter devoted to air pumps. The "Radojet," a purely American steam-jet air pump of recent development, is described.

On page 531 appears the statement: "No better material than admiralty brass has been found, and it is the standard for modern condenser practice." The reviewer believes that it should be made clear that while this is true for salt water, Muntz metal is now the standard for condenser tubes passing fresh water.

Except for the fore part, the chapter on steam turbines is wholly descriptive, with too much omitted about turbine oiling systems which, by the way, are not as broadly treated of in the chapter on lubrication as one wishes. So far as the reviewer knows, nothing has transpired to impair the hopes engineers have in the Ljungström turbine, yet no mention of it is found in the chapter dealing with turbines.

This fifth edition is indeed a creditable work and the reviewer regrets that space forbids more about it here. Reviewing it is like eating peanuts—one does not want to stop. The subjects embraced are so numerous and well presented that only in rare instances does one care to criticize; but rather, to suggest at these places, realizing the enormity of the fatiguing task of compiling such numerous and varied data. Chapter XVIII, pp. 845-890, on Finance and Economics—Cost of Power, is, in the reviewer's mind the best extant. Mr. Gebhardt is to be congratulated.

Obituary

Adam Cook, the senior member of the firm of Adam Cook's Sons, manufacturers of Albany grease, died on Feb. 19, at his residence, 148 West 78th St., New York City, after an illness extending over a period of seventeen weeks. Adam Cook was born in Albany, N. Y., in 1867, and was a graduate of the Albany Military Academy. At an early age he became a member of the firm of Adam Cook's Sons, which his father founded at Albany, in 1868.

Personal

Harrison Williams has succeeded Samuel Scovil as president of the Cleveland (Ohio) Electric Illuminating Co.

H. P. Curtiss has been appointed representative for the New England States of the Clarage Fan Co., of Kalamazoo, Mich., with office at 120 Milk St., Boston, Mass.

J. S. Green, formerly erecting engineer and master mechanic for the Wickwire Steel Co., of Buffalo, N. Y., has resigned to accept a position as master mechanic for the Edgewater Steel Co., Pittsburgh, Penn.

Engineering Affairs

The New England Water Works Association will hold a meeting on Mar. 13, at the Hotel Brunswick, Copley Square, Boston, Mass.

The American Society of Mechanical Engineers announces the following Section meetings: Baltimore, Md., Mar. 13; Chicago, Mar. 15; Philadelphia, Mar. 26; Bridgeport, Conn., Mar. 27.

The New York Chapter of the American Association of Engineers will hold its next regular meeting on Mar. 13, at the McAlpin Hotel. E. W. McKnight, of the First Canadian Expeditionary Forces, will speak on "War-Time Experiences."

The American Institute of Electrical Engineers announces the following Section meetings: Baltimore, Md., Mar. 18; subject, "Air Brakes;" Chicago, Mar. 25; subject, "Electrochemical Processes," by Charles F. Burges; Portland, Apr. 2.

The Minnesota Electrical Association will hold its annual convention at the Hotel Radisson, Minneapolis, Mar. 11-13. Among the important papers to be presented are "Minnesota Water Powers," by R. J. Thomas, superintendent of the St. Anthony Falls Water Power Co., and "Iron-Wire Transmission," by Prof. W. T. Ryan, of the University of Minnesota.

The American Institute of Electrical Engineers will hold an inter-section meeting in Pittsburgh, Apr. 9 and in New York, Apr. 12. Two papers will be presented: "The Physical Conception of the Operation of the Single-Phase Induction Motor," by B. G. Lamme; and "The Theory of the Phase Converter and the Single-Phase Induction Motor," by R. E. Hellmund.

Miscellaneous News

Boiler Explosion Kills Three in Providence—The explosion of a boiler in the Mount Pleasant Laundry, Providence, R. I., Monday, Mar. 4, is reported to have killed three persons, injured four and completely wrecked the laundry building. A "Power" representative is now after the details of the explosion.

A Heating Boiler Exploded at the Crown garage, Main St., Peoria, Ill., on Feb. 20, wrecking the back wall of the garage, shattering the boiler walls into thousands of pieces and doing damage estimated at nearly $10,000. The boiler has only been installed a year, and the cause of the explosion is unknown.

A Boiler Exploded at the sawmill of James Roberts, seven miles northeast of Clanton, Ala., on Feb. 26, instantly killing three workmen and injuring several others. There were two big boilers standing side by side at the mill, and from some unknown cause one of them exploded with such terrific force that it caused the other boiler also to blow to bits, breaking its iron part.

Business Items

Flynn & Emrich Co., of Baltimore, Md., are manufacturing the Huber hand stoker, which was formerly made by the Huber Grate Bar and Stoking Co., a description of which was published on page 665 of the Nov. 4, 1913, issue of "Power." It will be remembered that the movement of the grate advances the coal to the rear of the furnace, sifts out the ashes, and at the same time breaks up the fire. The movement of the grate is accomplished by levers operated from the front of the boiler.

The Schütte & Koerting Co. will continue business in all its lines and to its full capacity, as always, under a board of directors reconstructed as follows by the Alien Property Custodian of the United States: E. Pusey Passmore, governor of the Federal Reserve Bank, Philadelphia; Ralph J. Baker, assistant general counsel of the Alien Property Custodian; D. W. Hildreth, treasurer of Schütte & Koerting Co.; T. H. Johnston, of Schütte & Koerting Co.; Charles S. Caldwell, president, Corn Exchange National Bank, Philadelphia. The new board has elected the following officers: President, Charles S. Caldwell; treasurer, D. W. Hildreth; secretary, Ralph J. Baker.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago
Buckwheat ..	$4.60	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.10	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	3.90	.....	.....	.....
Barley	3.60	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Bituminous not on market.

	F.o.b. Mines*		Alongside Boston†	
	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago
Clearfields....	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets...	.....	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago
Pea	$5.05	$4.00	$5.80	$7.25—7.50
Buckwheat ..	4.30—5.00	2.75	5.50—5.80	7.00—7.25
Barley	3.25—3.50	1.95	4.00—4.25	4.00—4.25
Rice	3.75—3.95	2.20	4.50—4.80	5.00—5.50
Boiler	3.50—3.75	2.20	.....	3.50—4.00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate).....	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago
Pea	$3.75	$2.80	$4.65	$3.70
Barley	2.15	1.85	2.40	2.05
Buckwheat	3.15	2.50	3.75	3.40
Rice	2.65	2.10	3.65	3.00
Boiler	2.45	1.95	3.55	3.15

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.35—3.50
Mine-run	2.40—2.55	3.10—3.25
Screenings	2.15—2.30	2.85—3.00

Smokeless Coals	So. Illinois, Pocahontas, Pennsylvania and West Virginia	Hocking, East Kentucky and West Virginia Splint
Prepared sizes	$2.60—2.85	$2.85—3.35
Mine-run	2.40—2.60	2.60—3.00
Screenings	2.10—2.55	2.35—2.75

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago	Mar. 7, 1918	One Year Ago
6-in. lump..	$2.65-2.80	$3.25-3.50	$2.65-2.80	$3.25-3.50	$2.65-2.80	$2.50-2.75
2-in. lump..	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Steam egg ...	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Mine-run ...	2.40-2.55	2.75-3.00	2.40-2.55	3.00	2.40-2.55	2.25-2.50
No. 1 nut	2.65-2.80	3.25-3.50	2.65-2.80	3.25-3.50	2.65-2.80	2.35-2.75
2-in. screen .	2.15-2.30	2.50-2.75	2.15-2.30	2.75-3.00	2.15-2.30	2.25-2.50
No. 5 washed	2.15-2.30	3.00	2.15-2.30	2.75-3.00	2.15-2.30	2.50

Williamson-Franklin rate St. Louis, 87½c.; other rates, 72½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Cal., Oakdale—An agreement has been reached between the Sierra & San Francisco Power Co. and the Oakdale and South San Joaquin Irrigation Districts by which the power company will build reservoir on the south fork of the Stanislaus River. This work will be followed by that of doubling the output of the hydro-electric plants. Estimated cost, between $2,000,000 and $3,000,000.

Calif., Redding—City plans to sell $40,000 bonds to build an electric-lighting plant soon. W. D. Tillotson, City Attorney.

Calif., Sacramento—The Pacific Gas and Electric Co. plans to extend its transmission line from here to Guinda, Humsey and Brooks. C. W. McKillip, Mgr.

D. C., Wash.—A. L. Flint, Purchasing Agent, Panama Canal, is in the market for generator sets, copper cable, transformers, etc.

Ga., Sandersville—City plans to rebuild its electric-light and water plants which were recently destroyed by fire. I. N. Lozier, Supt.

Ill., Evanston—The Public Service Co. of Northern Illinois, Chicago, plans to build an extension to its transmission line from Evanston to Highland Park. G. H. Lukes, Gen. Supt.

Ill., Grafton—The Grafton Electric and Power Co., recently incorporated, plans to build an electric-lighting plant here. W. Chapman, Jerseyville, Attorney.

Kan., Dighton—City plans election soon to vote on a bond issue for enlarging its electric-lighting and water-works system. D. E. Bradstreet, Mayor.

Ky., Greenville—The W. G. Duncan Coal Co. is having plans prepared by C. M. Means, Engr., Oliver Bldg., Pittsburgh, Penn., for the erection of a new 1-story, 60 x 80-ft. brick and steel power plant.

Neb., Clarkson—City plans to extend and improve its electric-lighting plant. L. J. Roubineck, Supt.

Neb., Juniata—City voted $7000 bonds at a recent election for the erection of a transmission line from here to Hastings; also the installation of an electric lighting system. Noted Feb. 8.

N. Y., Chenango Forks—The Binghamton Bridge Co., Press Bldg., Binghamton, will not receive bids in April for the erection of a brick and steel power house, steel penstocks, etc. When plans have matured, the work will be done by their own forces. Noted Feb. 26.

N. Y., Clyde—The Clyde Glass Works plans to remodel its plant and completely re-equip same by installing power plant with 500 hp. capacity.

N. Y., Buffalo—(East Buffalo)—The Delaware, Lackawanna and Western R.R. is in the market for power plant equipment. G. J. Ray, Hoboken, Ch. Engr.

Ohio, Salem—The Salem Lighting Co. has been authorized by the War Department to build a power line from here to the Morgan plant at Alliance.

Okla., Ada—The Oklahoma Power and Transmission Co. plans to build a transmission line to supply the surrounding towns with current.

N. H., Claremont—The Claremont Power Co. plans to equip a new substation. J. G. Menut, Mgr.

Penn., Coudersport—The Home Electric Co. plans to issue $22,000 bonds; the proceeds will be used to extend and improve its plant and system. D. B. Belknap, Mgr.

Penn., Indian Creek—The Mountain Water Supply Co. is having plans prepared by King & Wightman, Engrs., 1513 Walnut St., Philadelphia, for a new 30 x 70-ft. power plant to be erected soon.

Penn., Philadelphia—The Coca Butter Manufacturing Co. is having plans prepared by A. F. Sauer & Co., Engr., 908 Chestnut St., for a new 1-story, 30 x 60-ft. brick power house to be erected at 2626 Martha St.

Penn., Pittsburgh—The West Penn Power Co. has been authorized by the Public Service Commission, to issue $1,500,000 bonds; the proceeds will be used to extend and improve its plant and system.

S. D., Newark—L. Severson has gained control of the electric-lighting plant here and plans to increase the capacity of the plant by installing new machinery.

Penn., Williamsport—The Lycoming Rubber Co. is having plans prepared by Lockwood Greene & Co., Engrs., 60 Federal St., Boston, for the erection of a 1-story brick and steel power house. H. S. Marlor, Supt. Noted Jan. 29.

S. D., Scotland—City plans an election to vote on the issuance of $35,000 bonds for the erection of an electric-lighting plant.

Wis., Brodhead—The Brodhead Electric Light and Power Co. plans to rebuild and remodel its electric-lighting plant. K. Guelson, Supt.

N. S., Halifax—The Department of Public Works plans to build an electric-lighting plant. L. F. Monashan, Clerk.